BIOPHYSICAL CHARACTERIZATION OF FLOATING WETLANDS (FLOTANT) AND VEGETATIVE SUCCESSION OF A WARM-TEMPERATE AQUATIC ECOSYSTEM

By

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TABLE OF CONTENTS

ACKNOWLEDGMENTS ii

ABSTRACT v

CHAPTERS

1 INTRODUCTION 1

Nomenclature 3
Components of Buoyancy 5
Formation Processes 9
Flotant Effects on Succession 11
Orange Lake Study Site 14
Study Objectives 17

2 INFLUENCE OF FLOTANT ON VEGETATIVE COMPOSITION OF A NORTH FLORIDA LAKE 19

Introduction 19
Materials and Methods 22
Results 30
Discussion 43
Conclusion 48

3 LOW COMPRESSION CORER AND SUBSURFACE VIEWER FOR SAMPLING FLOATING WETLANDS 50

Introduction 50
Design and Procedures 53
Discussion 70

4 PROFILE CHARACTERISTICS AND MAT COMPOSITION OF FLOTANT: IN ORANGE LAKE, NORTH CENTRAL FLORIDA 72

Introduction 72
Materials and Methods 76
Results 81
Discussion 105
Conclusion 111

5 BUOYANCY COMPONENTS OF FLOTANT AND EMERGENT WETLANDS IN A SHALLOW, WARM-TEMPERATE LAKE 113

Introduction 113
Materials and Methods 115
Results 127
Discussion 137
Conclusion 143

6 HISTORIC EVIDENCE OF FLOTANT COMMUNITIES IN A SHALLOW, WARM-TEMPERATE LAKE 145

Introduction 145
Materials and Methods 148
Results 153
Discussion 160
Conclusion 163

7 TEMPORAL AND SPATIAL DYNAMICS OF FLOTANT IN A SHALLOW, WARM-TEMPERATE LAKE 165

Introduction 165
Materials and Methods 167
Results 173
Discussion 196
Conclusion 204

8 SUMMARY AND CONCLUSIONS 206

APPENDIX A 213

APPENDIX B 231

APPENDIX C 248

APPENDIX D 272

APPENDIX E 355

LITERATURE CITED 405

BIOGRAPHICAL SKETCH 415

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Floating wetlands (defined as "flotant") are formed from macrophytes and/or organic substrate floating at or near the water surface, and occur globally in many wetland and aquatic ecosystems. Formation of flotant results in hydropattern changes that can significantly alter the structure and function of pre-existing communities and can influence successional development. Undesirable effects of flotant on lake access, navigation and possible impact on fisheries make these successional processes often incompatible with management objectives. Orange Lake, located in southeastern Alachua County, Florida, has an anecdotal history of flotant dating back to the mid 1800's. The incompatibility of fisheries objectives and the unknown implications of the desire to stabilize lake water levels prompted the need to understand and characterize flotant occurring on the lake. The overall objectives of this research are to determine 1) the influence of flotant on lake vegetation, 2) below-water profile characteristics of flotant, 3) the components of flotant buoyancy, 4) the mobility of flotant communities, and 5) whether physical evidence of flotant history exists in lake sediments.

Sixty-five sites were sampled. Vegetative species richness and components of buoyancy were measured within a 2 m^2 quadrat. At 30 sites, sediment ^{14}C dating and macro- and microscopic fragment analysis were conducted. Aerial photographs from January 1994; June 13, 1996; July 23, 1996; and September 24, 1996 were used to quantify mobility of flotant.

Fifty-nine species were identified in the 11 communities surveyed. Twenty-three of these were associated exclusively with flotant, indicating a significant increase in species richness at Orange Lake due to flotant. Positive buoyancy of organic flotant was principally the result of sediment gases, while that of vegetative flotant was below-water biomass. Reversals in chronology of ^{14}C dates and occurrence of root-dominated horizons suggest mass translocation of sediments in the lake resulting in bathymetry changes and increased landscape vegetative heterogeneity. Between 1994 and 1996 emergent marsh and flotant community cover decreased by 149 ha. Fragmentation of marsh flotant resulted in increased mobility of flotant within the open water zone of the lake. Increased flotant mobility may have decreased lake access and navigation, but may also increase fish movement between the open water and the near-shore breeding habitat.

CHAPTER 1
INTRODUCTION

One wetland community that is not characteristic of bottom-rooted emergent wetlands, is that of floating wetlands. The unique characteristics of floating wetlands are not manifestations of otherwise unidentified species, biogeochemical processes or even faunal habitat, since similar species, processes and habitat occur in emergent wetlands of equivalent geographic distribution. Instead, the uniqueness of these wetlands is their autogenic influence on hydrologic parameters including frequency, duration, depth and seasonality of inundation. Since hydropattern is known to be of primary importance in determining many wetland processes and species distribution, the formation of floating substrate often results in characteristics that are in stark contrast to that of adjacent, nonfloating, aquatic or wetland areas. These characteristics include composition and persistence of vegetation (Glasser, 1986; Hill et al., 1987; Ellery et al., 1990), type and intensity of biochemical processes (DeLaune et al., 1986; Haraguchi, 1991a; 1992; Haraguchi and Matsui 1990), and type of habitat for faunal species (Reid, 1952; Southern et al., 1986; Oliver and McKaye, 1982).

Formation of floating wetlands is global in distribution, and not restricted to a range of latitude, or trophic condition. Floating peatlands and floating Sphagnum bogs have been described in temperate zones [Lieffers, 1984 (Alberta, Canada); Hogg and Wein, 1988a, 1988b (New Brunswick, Canada); Verhoeven, 1992 (Holland); Zimmerli, 1988 (Switzerland); Pallis, 1915 (Romania); and Taylor, 1976 (Tasmania)]. Floating organic substrate marshes and islands identified in subtropical systems (Tur, 1972 (N. Argentina); Reid, 1952; Glasser, 1986; Stenberg and Clark, 1998; (southeast United States). The greatest documentation of floating wetlands occurs in tropical regions [Gaudet, 1976, 1977a (Africa); Denny, 1984 (Sudan); Ellery et. al., 1990 (Botswana); Goeltenboth, 1982 (Java); Kaul and Zutshi, 1966; Trivedy et al., 1978 (India); Junk, 1970 (Brazil); Southern et al., 1986 (Fiji); Hill et al., 1987 (Northern Territory, Australia)].

The primary distinction between floating and emergent wetlands is to some extent arbitrary, and as yet does not have a universally accepted definition. This is in part due to regional differences and limited discussion among scientists to develop a classification system of floating wetlands (Mitsch and Gosselink, 1993; Ellery et al., 1990; Junk, 1983; Oliver and McKaye, 1982; Cypert, 1972; Sasser, 1994). For this research a general working definition is proposed that encompasses most of the wetland types identified in the literature. In addition the term "flotant," first introduced to describe floating marsh wetlands in the Louisiana Delta (Russell, 1942), will be used when referring to communities that develop under floating substrate conditions. Flotant is defined as macrophytes and/or substrate that float within the water column and that lack sufficient connectivity with bottom sediments to restrict vertical movement in response to fluctuations in water level or changes in buoyancy.

Flotant can occur under a broad continuum of vegetative, hydrologic, substrate and buoyancy variables. These variations are often the result of distribution of flotant in different types of ecosystems. To simplify this continuum, identifying characteristics of floating wetlands at either end of the spectrum will provide some insight into variability of these wetlands, and those components that provide buoyancy. At one extreme of the continuum, flotant is composed exclusively of vegetative material. This type of flotant often is dominated by prostrate-stemmed hydrophytes that have entangled roots and stems and can form a dense mat that floats at the surface (Conway, 1949; Swan and Gill, 1970; Junk, 1983; Huffman and Lonard, 1983; Mitchell, 1985; Thompson, 1985; Ellery et al., 1990). Examples of species forming this type of flotant community in Florida include *Hydrocotyle umbellata*, *Eichhornia crassipies*, *Limnobium spongia* and *Scirpus cubensis*. At the other extreme, flotant is composed predominantly of organic substrate up to several meters thick, with or without rooted vegetation (Cypert, 1961, 1972; Tallis, 1983; Thompson, 1985; Glasser, 1986). This type of flotant is buoyed principally by gases trapped within the substrate matrix (Hogg and Wein, 1988a). Organic substrate flotant is often more stable, less frequently inundated and has a different hydropattern than that of flotant, which is strictly vegetative in nature.

Nomenclature

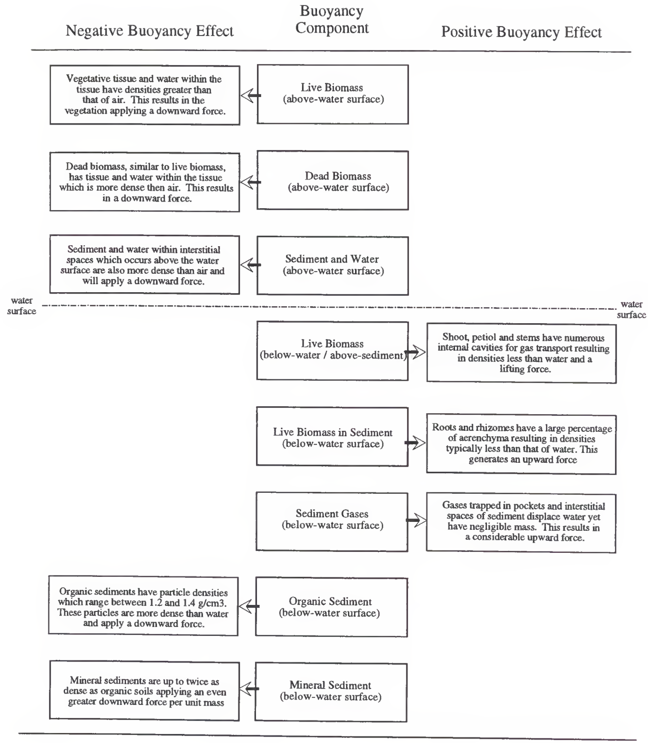
Numerous terms have been used to define flotant, terminology differences result from true differences in type of floating communities and regional vernacular. The most common terms in the literature are identified below before defining the terminology. A term used in Argentina, “Comolatalas,” is translated as "associations of floating hydrophytes" and appears to describe only mats with vegetative components that have little peat or organic sediments (Tur, 1972). Mats that have higher organic contents are termed “Embalsados” by the same author and are defined by the author as " floating masses composed of joined palustrin plants in which the roots retain various quantities of detritus organics and minerals" (Tur, 1972). In the upper Nile River, islands of floating vegetation were described as "Sudd" by earlier explorers, the root of the word meaning blockage in Arabic (Whigham et al., 1987). In Germany, "Schwingmoor" describe floating mats and “schwimmkampen” describes floating islands (Mueller et al., 1996). Floating reed swamps along the Danube delta are termed "plaur" (Pallis, 1915). In North America, French trappers termed the floating mats of the coastal marshes of southern Louisiana, "flotant" (Russell, 1942). Translation of the Indian name for the large bog fen complex in southern Georgia, "Okefenokee" has been interpreted as "trembling or quaking earth" which could easily describe walking on flotant. More recent terms describing organic mats that form in the Okefenokee National Wildlife Refuge are "peat battery," "peat bulge," "floating mat" or "aggregate mat" (Glasser, 1986). The term “floating meadows” has been used to describe *Paspalum* and *Echinochloa* marshes in the Middle Amazon (Junk, 1970; 1973; Engle and Melack, 1993). The term often used for more mobile forms of floating vegetation surrounded by water is “floating islands” (Oliver and McKaye, 1982; Reid, 1952; Powers, 1914; Trivedy, 1977; Little, 1969; Terry and Minto, 1970), or in Japan Ukishima (Mueller et al., 1996). Areas not surrounded by open water that are attached to the shoreline often are called “floating marshes” (Sasser et al., 1991; Sasser et al., 1995), “floating vegetation mats” (Hill et al., 1987; Huffman and Lonard, 1983), “floating wetland mats” (Stenlund and Charvat, 1994), “floating Typha mats” (Hog and Wein, 1987) or simply “floating mats” (Mallik, 1989). In systems dominated by peat, terms that have been used are “floating peat mat” (Haraguchi, 1991b) and “floating peatland” (Wilcox and Simonin, 1988). Flotant communities in Florida, including Orange Lake have been referred to as “tussocks”(Alam et al., 1996; Moyer, 1995). Although other terms exist and the regional application of these names may help to define the physical and vegetative composition of the mat, a definitive nomenclature of the composition and vegetative development on floating substrates has not been established. In this dissertation I use the following terminology to describe the multiple types of floating substrate being investigated.

The term flotant is used to describe all types of floating substrates whether they are strictly vegetative or they have organic sediment as part of their composition. The terms organic and vegetative are used to discriminate between flotant predominantly composed of live vegetative material (vegetative) and flotant that is composed predominantly of organic sediments (organic). Flotant that is not attached to the shoreline and is able to move freely in open water is called an island. Flotant that is attached to the shoreline and is restricted in horizontal movement is called a marsh (if mostly herbaceous) or swamp (if mostly woody). If the flotant is dominated by a single species of vegetation, the genus of that species is included in the descriptor of that name. As an example of this system of nomenclature, the classification "*Typha* organic island flotant" implies that the community is characterized by floating organic substrate dominated by *Typha* that is not attached to the shoreline. Although somewhat cumbersome, this system provides a more descriptive characterization of the types of flotant being discussed.

Components of Buoyancy

A knowledge of the buoyancy components present in wetlands, the physical processes at work at these sites and the complex interaction of buoyancy and biogeochemical variables are paramount in understanding the dynamics of flotant wetlands. Simply stated, an object floats when the mass of an object is less than the mass of the fluid it displaces. Therefore, when a floating object is at rest in a fluid, it has reached equilibrium between the mass of fluid displaced by the object and the mass of the object. These counteracting forces, upward (fluid displacement) or downward (mass of object), are distributed over a given area and the resulting units are mass per unit area. These two forces typically are not separated and are known collectively as buoyancy. An object that does not float because its mass is greater than the mass of the fluid it displaced is said to have negative buoyancy. Conversely, an object that floats is said to have positive buoyancy.

Application of the principals of buoyancy to determine why flotant is floating, or perhaps why an emergent marsh is not floating, requires identification of those components that affect buoyancy. Using an emergent marsh site as an example, three components of positive buoyancy and five components of negative buoyancy can be identified (Figure 1). Components occurring below the water surface with densities less than that of water provide positive buoyancy to the site. These include gases trapped in the sediment matrix, below-water and/or below-substrate roots and rhizomes, and below-water, but above-substrate shoots, culms and stems. These three components all have characteristics that displace a large volume of water while having a relatively small amount of mass. This results in an upward force and a positive contribution to net buoyancy. Components below the water surface with densities greater than water, such as organic and mineral sediments, create a negative buoyancy effect. Above the water surface, components would have to be less dense than air to provide positive buoyancy to the site. Therefore, live and dead biomass above the water surface as well as any sediments and interstitial water above the water surface produce a negative effect on buoyancy.



Negative Buoyancy Effect	Buoyancy Component	Positive Buoyancy Effect
Vegetative tissue and water within the tissue have densities greater than that of air. This results in the vegetation applying a downward force.	Live Biomass (above-water surface)	
Dead biomass, similar to live biomass, has tissue and water within the tissue which is more dense then air. This results in a downward force.	Dead Biomass (above-water surface)	
Sediment and water within interstitial spaces which occurs above the water surface are also more dense than air and will apply a downward force.	Sediment and Water (above-water surface)	
water surface		water surface
	Live Biomass (below-water / above-sediment)	Shoot, petiol and stems have numerous internal cavities for gas transport resulting in densities less than water and a lifting force.
	Live Biomass in Sediment (below-water surface)	Roots and rhizomes have a large percentage of aerenchyma resulting in densities typically less than that of water. This generates an upward force
	Sediment Gases (below-water surface)	Gases trapped in pockets and interstitial spaces of sediment displace water yet have negligible mass. This results in a considerable upward force.
Organic sediments have particle densities which range between 1.2 and 1.4 g/cm3. These particles are more dense than water and apply a downward force.	Organic Sediment (below-water surface)	
Mineral sediments are up to twice as dense as organic soils applying an even greater downward force per unit mass	Mineral Sediment (below-water surface)	

Figure 1. Eight components of buoyancy that can occur in flotant or an emergent wetland community. Each component has either a positive effect (right column), or a negative effect (left column), on net buoyancy of a site. Modified from Hogg and Wein (1988).

Compartmentalizing overall site buoyancy into these separate compartments creates the impression of a static character to site buoyancy. Many of the components of buoyancy however are quite dynamic and can change seasonally or on a daily basis. As an example, components that are positively buoyant below water, such as below-water shoots, can become negatively buoyant if the water level decreases or if a floating mat rises (thus placing the component above water). Conversely, above-water components, which are all negatively buoyant, can reverse part of the buoyancy and become positive if portions of the stem are submerged during water-level rise or sinking of a mat. Several studies have identified seasonality in mat formation and subsidence that is principally correlated to the effect of temperature changes on gas components of a site (Powers, 1914; Glasser, 1986; Hill et al., 1987; Haraguchi, 1991a, 1991b). This effect can be direct due to the relationship between gas volume and temperature, or indirect due to microbial activity stimulation and the resultant production of gaseous byproducts. Seasonal changes in vegetation, especially in areas that have an annual dieback of vegetation, can shift the relative importance of biomass as a contribution to buoyancy (Hogg and Wein, 1987). Therefore, any quantification of buoyancy is limited in interpretation to a single point in time, and it is important to realize that changes in contribution by components of buoyancy are likely to occur.

Although these parameters represent the components of flotant that interact to determine whether a site will float or not, only one previous study has measured and quantified these components. This study was conducted on *Typha* organic marsh flotant in New Brunswick, Canada (Hogg and Wein, 1988a). Findings indicate that 92% of the buoyancy of that flotant was the result of gases within the sediment matrix. However, this was one study of one type of flotant. A more general understanding and widespread investigation of flotant buoyancy, and how buoyancy components change with time to influence formation and auto regulate hydropattern, is imperative to understanding these wetland communities.

Formation Processes

Formation processes of flotant are not well understood and are described mainly on hypothetical scenarios. As indicated in the discussion of buoyancy components, the ability of flotant to form is the net result of positive components of buoyancy becoming greater than negative components of buoyancy. Therefore, the process or mechanisms related to buoyancy must be related to the dynamic change in buoyancy components that ultimately lead to a net positive buoyancy of vegetation and/or sediment. In wetland and aquatic ecosystems where floating wetlands occur, three broadly defined formation mechanisms have been proposed. These three mechanisms are classified based on the presence or absence of vegetation at the time of initial formation.

The first type results from the flotation of unvegetated organic substrates that typically delaminate from deeper organic or mineral horizons. This formation type has been proposed in the Okefenokee Swamp (Cypert, 1972; Glasser, 1986; Little, 1969; Ellery et al., 1990) the Louisiana delta (Sasser, 1994) and various other areas including Orange Lake (Barbor, 1944). Because there is no vegetation initially rooted in the substrate, buoyancy is most likely provided by gases within the sediment matrix. Mechanisms that have been proposed to explain increased gas buoyancy, but not tested, are increased microbial gas production, expansion of gases due to increased temperature and reduction in the rate of gas release. (Hogg and Wein, 1988a; Sasser, 1994). Because gases are the only component initially, and likely the principal buoyancy component even after vegetation is established, these types of floating islands can be significantly influenced by environmental conditions that effect the rate of gas production, the rate of release and sediment internal matrix volume available for storage.

At the other extreme in types of flotant, vegetation that is positively buoyant and morphologically adapted to floating conditions can form dense stands of vegetative flotant. Such vegetative communities form as the result of unattached free floating aquatic vegetation becoming consolidated in low energy areas. However, these wetlands may also require an initial colonizing site or nucleus before growth can take place, such as floating organic sediments or attachment to the shoreline (Ellery et al., 1990). Vegetative morphological characteristics common to this type of flotant include long prostrate stems, petioles, roots perpendicular to the stem or stolon, and extensive fine root system. After the initial establishment of one or more of these well adapted free floating species, leaf and stem litter can accumulate, depending upon environmental conditions, and provide a substrate for colonization by other species less adapted to establishment in open water conditions. Examples of this type of formation are often related to invasive exotic species such as *Eichhornia crassipies* or *Pistia stratiotes* in Florida. However, indigenous species in undisturbed locations can also form vegetative flotant as exemplified by *Eichhornia azurea* and *Scirpus cubensis* in Brazil (Nogueira et al., 1996), or *Limnobium spongia* or *Hydrocotyle* sp. in Florida.

A third class of flotant is identified based on the presence of both vegetation and organic substrates. Buoyancy of these wetlands is a combination of vegetative components and sediment gases. The formation of flotant of this type in the Louisiana delta has been attributed to the subsidence of mineral sediments (Sasser, 1994; O'Neill, 1949). As water depth increases due to the subsidence of mineral sediments, the pre-inundation negative components of stem buoyancy shift to positive components after inundation. If this shift creates a greater positive force than the negative components in the sediment, the site will float. Rising water levels independent of sediment subsidence can also result in the formation of floating wetlands and were identified as the formation mechanism of floating marshes dominated by *Typha* x *glauca* in New Brunswick, Canada (Hogg and Wein, 1987; Krusi and Wein, 1988). Formation by this third mechanism, however, may not be exclusively linked to changes in water level. Any reduction in the holding continuity of the sediments or connectivity of the root zone could also result in the formation of flotant, provided positive buoyancy of the site was greater than negative components after connectivity and cohesion of sediments was compromised.

Although the initial formation of floating wetlands tend to fall within one of these three general groupings, successional processes may result in a continuum of characteristics, from strictly vegetative or organic substrate, to a varying degree of vegetation and substrate. What specific mechanisms of formation, what components increase in positive buoyancy or what components decrease in negative buoyancy to initiate flotant formation has also not been addressed in the literature and is critical information to reduce or promote the formation of these communities.

Flotant Effects on Succession

In temperate systems, a classical model of autochthonous peatland-lake development indicates a strong connection between flotant and succession in these systems (Whittaker, 1975; Kratz and DeWitt, 1986). In this model three stages of development are identified which occur along a horizontal transect from open water to the shoreline. The first zone is a "zone of thickening" consisting of a vegetative floating wetland that encroaches horizontally into open water at the surface and expands vertically by thickening. Sediment falling from this zone of the marsh flotant also thickens the bottom sediments, reducing the free-water space below the mat. The second zone, typically landward of the first, is the "zone of compaction". This zone is characterized by a lack of a free-water space below the flotant, the presence of organic sediments within the mat and a bottom substrate of less than maximum density. Lower densities of these sediments result from organic deposits on the floating mat being pulled apart by gravity instead of being compressed. As new litter and organic material is deposited, the sediment surface remains constant, thus compacting the sediment layers below. The third stage of development is the "zone of equilibrium." This zone is characterized by no net peat accumulation because sediments are at a maximum density and no additional compaction can occur below-water. Additional litter accumulation would have to occur above the water surface in more aerobic conditions, where production and decomposition of organic compounds are at equilibrium. The result of this successional process through the three floating wetland classes and eventually into an emergent marsh is a steady reduction of open water and a conversion to peatlands.

The role of floating wetlands in the development of tropical and subtropical lakes is not well understood and few studies have addressed this subject. However, in several prominent wetland ecosystems of the southeastern United States, influence of flotant on vegetative development and landscape scale structural heterogeneity is thought to be significant. In the Okefenokee swamp, Glasser (1986) hypothesized that organic flotant significantly increased the spatial heterogeneity of vegetation within Chase Prairie identifying several autogenic processes such as litter accumulation, shading and perching sites which influenced genetic recruitment and vegetative succession on the floating peat batteries. Mat formation providing viable germination sites within a predominantly flooded landscape also preserved the distribution of short-lived species in the seed bank. Over longer time scales, changes in vegetative community on floating mats leading to tree island development, a predominant landscape feature of the Okefenokee Swamp have also been proposed (Cypert, 1972, Rich, 1979; Glasser, 1986; Duver and Riopelle, 1983). Similar developmental pathways have been proposed in the Loxahatchee National Wildlife Refuge and parts of the Florida Everglades (Davis, 1943; Cohen and Spackman, 1970; Gleason et al., 1980;). In these areas, formation of organic flotant and associated vegetation were hypothetically and experimentally identified as precursors or nuclei to tree islands and hummocks of small to medium size (Gleason et al., 1980). These features in the landscape are no longer free floating, but have sunk or become grounded. However, in the absence of a topographic high created by translocation of sediments by flotant or suitable conditions for germination created while the site was still floating, succession along this pathway may not have occurred. In addition, because formation of flotant is often patchy, effects of flotant on vegetative succession increases the spatial heterogeneity of species and structure within the landscape. Understanding how flotant communities may influence long-term successional pathways and therefore features and structure of wetland and aquatic ecosystems is paramount in making sound management decisions that may increase or decrease the formation of flotant.

Orange Lake Study Site

Orange Lake and its associated wetlands are located in peninsular north central Florida in Alachua and Marion Counties (Figure 2). Depending upon water levels, the lake ranges between 1,600 and 5,600 hectares and lies within a sub-catchment covering approximately 350 km^2. Average open water depth within the lake is less than 2 meters and lake and marsh ecosystem substrates are characterized by thick organic muck and peat (Danek et al., 1997).

Hydrologic components of the lake, aside from rainfall and evapotranspiration, include surface water input from swamps and sloughs to the north of Orange Lake via the River Styx and from Lake Lochloosa via Cross Creek. Surface outflow is from the southeastern part of the lake via Orange Creek. There is also a significant loss through the sinkhole complex at Heagy-Burry park (especially during periods of low water tables). Natural variations in rainfall every 5 to 10 years result in periods of low water upward of 60 cm below the average. However, two relatively recent severe reductions in rainfall (1956-57 and 1990-91) resulted in water level drops of up to 1.5 meters below the norm.

Alterations in hydrology of the Orange Creek Basin have affected Orange Lake since the turn of the century (Robison, 1997). Increase in flows to the lake via the River Styx began in the 1920s with the construction of a canal to divert Newnans Lake water away from Paynes Prairie in order to drain portions of Paynes Prairie for pasture. This flow was later reduced in 1975 when a portion of the canal levee was breached and a control structure was constructed in an attempt to partially restore historic hydroperiods to Paynes Prairie. Outflow from Orange Lake at Orange Creek may have also been affected early this century due to the construction of a railroad trestle in 1918 and a

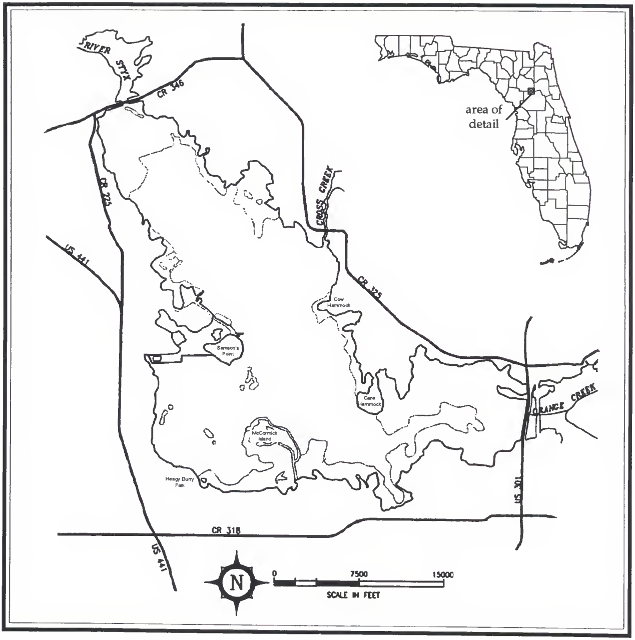


Figure 2. Map of Orange Lake located in southeastern Alachua county.

bridge and causeway for county road 301 in the 1920s. More significant alterations to the outflow at Orange Creek began in 1958 when an earth and rubble dam was placed across the outflow. In 1963 a steel piling and concrete weir was constructed with a low water notch elevation of 16.92 m NGVD. In 1990 the low water notch of this same weir was illegally filled which increased the outflow elevation to its present height of 17.40 m NGVD.

A prominent feature of Orange Lake and its fringing wetlands is the occurrence of floating marshes and floating islands. The occurrence of floating wetlands on Orange Lake in the middle of the last century is documented in an account by Major General George A. McCall (1868). Prior to his written documentation, reference to islands on Orange Lake relate to their use by Florida's early Indians as a place of burial (Freeman, 1960). More recently, documentation of the phenomenon of floating islands and floating marshes in Orange Lake is more prevalent. In *Ford Times*, a publication of the Ford Motor Company, the author briefly recounts the 1956 drought in Orange Lake, noting, "the lake's strange and fascinating floating islands were resting on an expanse of tinder-dry waste land" (Freeman, 1960). Two newspaper articles in 1976 (Abel, 1976; Gale, 1976) as well as Edwin Way Teale's (1951) "Lake of the Floating Islands" in *North With the Spring,* focused on Don McKay, a naturalist who observed the floating islands on Orange Lake for 30 years and offered guided boat and walking tours among the islands.

Aside from the attention flotant has received in the popular press, limited scientific research has been undertaken to address the role of island flotant and marsh flotant in the ecology of Orange Lake. In the early 1950s, Reid (1952) identified numerous vertebrate and invertebrate species utilizing the island flotant and listed vegetative species that were associated with these wetlands. In an earlier study by Reid

(1950a), an association of a certain community of fish with island flotant was also noted, where *Gambusia holbrooki*, *Heterandria formosa* and *Hololepis (Etheostoma) barratti* were often found at the edges of islands. Reid (1950b) also stated that these islands were used for reproduction by black crappie, which were noted to make redds under the edges of islands.

Over the past 8 years much of the interest in flotant in Orange Lake has focused on the possible expansion of this community and the impediment flotant can have on public access and navigation. Marsh flotant is also thought to be detrimental to fisheries production in the lake. These issues arose when an apparent expansion of flotant occurred with the return of normal water levels after the 1990-1991 drought. Another ongoing issue, reinforced by the drought, was a desire to reduce the duration of extended low water periods to facilitate access to the lake by fisherman. Several proposals to reduce the duration and extent of water levels in Orange Lake were identified and evaluated by lake managers. One issue, however, that became quickly apparent was the lack of basic knowledge about the flotant communities within the Orange Lake ecosystem.

Study Objectives

The specific need to provide managers with a better understanding of flotant communities on Orange Lake also provided an opportunity to utilize Organic Lake as a case study of flotant community development. To address the specific needs of lake management, five objectives were identified:

- To determine the effect flotant may have on the existing vegetation communities of Orange Lake.
- To characterize and classify below-water vertical profiles of flotant communities.
- To determine what components of flotant provide buoyancy and contrast these with non-flotant wetland and open water communities in an attempt to understand flotant formation mechanisms.
- To determine whether there is evidence of flotant formation within the lake sediments, and if this evidence is found can it be used to infer the role of flotant on successional development of the lake.
- To quantify spatial and temporal change of flotant communities within the open water areas of the lake.

Field sampling for the studywas conducted in two phases. The first phase was conducted between April 11, 1996 and November 18, 1996. The second phase was conducted between May 2, 1997 and July 18, 1997. The dissertation is organized into eight chapters. Chapter 2 describes the influence of flotant on vegetation composition of Orange Lake. Two pieces of equipment specifically designed for this research and investigations on flotant communities are discussed in Chapter 3. Profile characteristics and substrate composition of Orange Lake flotant are described in Chapter 4. Buoyancy components and implications for formation are described in Chapter 5. Chapter 6 discusses findings regarding historic evidence of floating wetland communities on Orange Lake. Chapter 7 describes temporal and spatial dynamics of flotant communities on Orange Lake, and Chapter 8 is a summary of findings.

CHAPTER 2
INFLUENCE OF FLOTANT ON VEGETATIVE COMPOSITION OF A NORTH FLORIDA LAKE.

Introduction

Formation of floating substrates can create hydrologic conditions suitable for vegetative establishment in areas otherwise uninhabitable due to excessive depth or duration of inundation. A term locally used in the Louisiana delta for these floating communities is "flotant" (Russel, 1942, Sasser, 1991) which generally describes any substrate floating at or near the water surface that supports macrophytes. Although terms such as Tussock, Floating Mats (Hogg and Wein, 1988, Hauffman and Lonard, 1983), Floating Island, Floating Marsh (Gosselink, 1984), and numerous other vernacular names have also been used to describe these wetland communities, the term flotant will be used in this paper as the most general classification of these communities. As defined, flotant includes all types of floating substrates and vegetation regardless of connection to shore line, horizontal mobility, association of organic sediment, or composition. (A more detailed explanation of the composition and structure of different types of flotant can be found in Chapter 4, and a discussion of other terminology used can be found in Chapter 1).

Flotant is unique with respect to its autochthonous influence on hydropattern. In the case of bottom rooted emergent vegetation, hydropattern is controlled principally by external factors, mainly that of climatic conditions and site elevation. However, in the case of flotant, hydropattern is principally influenced by mechanisms that regulate buoyancy, and are therefore less influenced by precipitation and site elevation. The most prominent component of buoyancy regulating flotant includes: gases trapped within the organic substrate and vegetation type (Hogg and Wein, 1988; Sasser et al., 1996; see Chapter 5 for specific buoyancy regulators of Orange Lake flotant). Seasonal changes in temperature can influence production rates and volume of gases causing islands to form and become more positively buoyant during periods of high temperature (Mitchell, 1985; Ellery et al., 1990). This results in greater positive buoyancy of the flotant, reduced inundation and increased exposure of organic substrates to the atmosphere. Buoyancy of flotant is also regulated by seasonal changes in vegetation growth rates. As seasonal changes in biomass occur, relative position of the floating substrate surface can change potentially becoming lower in the water column during summer and floating higher in the water column in the winter. (Hogg and Wein, 1988). The opposing influence of increased buoyancy due to sediment gases at higher temperatures and decreased buoyancy due to increased above-water biomass during warmer months often results in no net change in buoyancy. This however, is dependent upon the initial contribution to buoyancy of each component. Because buoyancy of flotant, and therefore saturation/inundation regime on substrate, can change as a result of factors not necessarily related to precipitation events or shoreline elevation, it is expected that hydropattern of flotant differs from that of non-floating, bottom substrate. This is hypothesized not just with respect to frequency, depth and duration of inundation, but also with regard to seasonal timing of inundation events.

The significant influence hydrology has on species selection (Van der Valk, 1986), distribution (Botts and Cowell, 1988) and productivity (Bayley et al., 1985) in wetland ecosystems will determine the species assemblage at a given location. Changes in hydropattern hypothesized to result from formation of flotant, also implies a potentially significant effect on vegetative community composition between flotant and non-floating substrates. Studies in the Okefenokee Swamp support this inference and indicate significant community shifts in species composition after the formation of floating organic substrate (Glasser, 1986). In this study a chronosequence of floating communities indicated that on floating mats that persist for greater then 3 years, woody vegetation and eventually tree house development dominated by *Taxodium ascendens* is likely to occur. (Glasser, 1986; Cypert, 1972). In non-floating areas adjacent to flotant, a wet prairie community dominated by *Nymphaea odorata* and *Orontium aquaticum* was present. These species are more tolerant of extended inundation and deeper inundation depths than those found on flotant. In-filling processes modeled in Boreal Peatlands also indicate the establishment of vegetative communities in locations otherwise not hydrologically compatible with vegetative inundation tolerance regimes in the absence of flotant. Formation of floating mats around the perimeter of small peatland lakes allow for the establishment of vegetation and colonization of open water areas even though the water column has not yet been completely filled in with sediments (Kratz and Dewitt, 1988). The alteration of hydropattern resulting from flotant formation changed the vegetative community composition from submerged aquatic or deep marsh species to shallow marsh or communities only tolerant of saturated substrate conditions.

Hydropattern changes that result when flotant is formed are hypothesized to alter the vegetative community composition of these communities. These changes in community composition will likely resemble shallow or intermittently flooded wetlands within the same regional ecosystem. However, because of the unique hydropattern that may exist as a result of autochthonous, and not alochthonous control of flotant hydropattern, it is also hypothesized that flotant formation may provide unique habitat conditions for some species otherwise not found in shallow lakes. The objectives of this study were to test this hypothesis by surveying existing floating and non-floating vegetative in Orange Lake. Specific questions addressed were: 1) are there differences in species composition and biomass between floating substrate and non-floating substrate communities, and 2) is there a difference in inundation tolerance of species found on floating substrate vs. non-floating substrate?

Materials and Methods

Study Site

Orange Lake is a warm-temperate lake in north central Florida approximately 18 kilometers south southeast of Gainesville. Lake size is 5,280 hectares at 17.65 NGVD, and water level over the past 50 years has ranged from 16.13 to 18.63 m NGVD (USGS). Hydrologic inputs to the lake are rainfall and overland flow into the northeast lobe via the River Styx. Outflow occurs via a sinkhole at Heagy Bury Park in the southwest lobe, and overland from the eastern lobe via Orange Creek (Figure 1). Average lake depth is less than 2 m (Robison et al., 1997). Lake trophic state since the early 1900s has been described as eutrophic according to diatom species assemblages in the sediments (Brenner and Whitmore, 1996). Sediments are predominantly sapric to hemic organics averaging

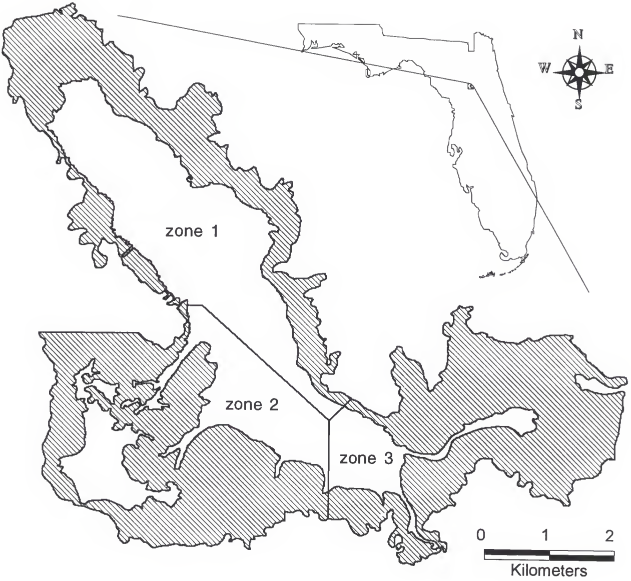


Figure 1. Map of Orange Lake depicting extent of fringing wetland communities (area with diagonal shading) and demarcation of lake zones used in stratified random selection of sampling sites.

1.35 m thick lake wide with some locations having depths exceeding 3.65 m (Danek et al., 1997).

The history of flotant on Orange Lake is documented back to 1792 when William Bartram surveyed this part of Florida (McCall 1868; Warr et al., 1999). Reversals in ^{14}C dates within the sediment profile, and peat stratigraphy of several sediment cores in Orange Lake, suggest relocation of organic sediments resulting from flotant occurred as early as 1580 ± 50 AD. (See Chapter 6). This evidence suggests organic flotant has been a factor in the development of the lake ecosystem for at least four centuries.

Two general types of flotant occur in Orange Lake, those having organic sediments as substrate, and those dominated by prostrate-stemmed hydrophytes with no appreciable sediment accumulation (Bryan, 1998; see chapter 3). Formation of organic flotant is principally the result of decomposition gases trapped within the organic sediment matrix, and secondarily due to below-water biomass (Hogg and Wein, 1988; see chapter 5). Buoyancy of vegetative flotant results strictly from positive buoyancy provided by below-water biomass of mat forming species (Thompson, 1985; see chapter 5). These two classes of flotant can be found either as floating marshes that are attached along the shoreline, or floating islands that float freely about open water areas or are surrounded by *Nuphar luteum*.

Site Selection

A previous vegetative survey by the St. Johns River Water Management District (Bryan, 1996) identified 18 vegetative community types occurring on Orange Lake. These communities were broadly grouped into five floating, two deep marsh, five emergent marsh, two scrub-shrub swamp, two forested and two open water communities.

Ten of these community types were selected for this study, all five of the floating communities, and five of the non-floating communities. Non-floating communities consisted of 1 deep marsh (2 combined from Bryan, 1998 survey), 1 scrub-shrub swamp (each was a combination of two separate communities classified by Bryan, 1998 survey) and three emergent marsh communities, (two combined from Bryan, 1998). Community type characteristics and classification criteria can be found in Table 1. Characteristics of each of these community types were determined based on dominant vegetation, type of floating substrate and whether or not the substrate was free floating or connected at some point along the shoreline. For each community type, six sample sites were selected in a stratified random manner. Site selection was stratified into three lake zones to reduce possible spatial effect (Figure 1). Location of each sample station within each lake zone was determined by overlaying a 500 x 500 m grid on the St. Johns River Water Management District vegetative map. Each grid internode was then numbered. Grid intersects were randomly selected until two sample sites for each community type were selected within each of the three lake zones. The grid intersection selection method could not be used to determine sampling sites for floating island communities due to their mobility. For these communities, a sampling day location method was developed. For floating organic islands and vegetative islands, a random azimuth heading was taken from the centroid of each lake zone to locate the sampling site. Once the azimuth heading was determined from the lake centroid, a transect 25 meters wide was followed until either the desired community type was intersected, or the open water/marsh edge was encountered. If the desired floating island community was found, a random fraction between 0.1 and 0.9 of the total transect distance across the island was calculated to demarcate the placement of the sample quadrat. The 0.0-0.1 and 0.9-1.0 fractions were

Table 1. Clasification criteria of wetland communities surveyed in this study. Criteria is based on substrate compositoin, connectivity to shoreline, and dominant vegetative species present.

Community type	Classification Criteria
Floating Communities	
Organic Island Flotant	Floating organic substrate surrounded by water or *Nuphar luteum,* vegetation varied low to tall macrophytes (*Eleocharis baldwinii, Amaranthus australis, Ludwigia leptocarpa. Eupatorium capillifolium*).
Vegetative Island Flotant	Floating vegetation with minimal accumulation of organic sediment, surrounded by water or *N. luteum*, vegetation dominated by *Limnobium spongia, Hydrocotyle* spp. *Polygonum densiflorum* and/or *Scirpus cubensis.*
Vegetative Marsh Flotant	Floating vegetation with minimal accumulation of organic sediment, floating mat attached to shoreline, vegetation dominated by *L. spongia* and/or *Hydrocotyle* spp.
Bulrush Marsh Flotant	Floating vegetation with minimal accumulation of organic sediment, floating mat attached along shoreline, vegetation dominated by *S. cubensis.*
Organic Marsh Flotant	Floating organic substrate, substrate attached along shoreline, vegetation rarely dominatted by a single species, *E. baldwinii, Decodon verticillatus*, *Bidens* spp. and *Ludwigia* spp. often present.
Non-Floating Communities	
Deep Marsh	Deep water bottom rooted wetland dominated by *N. luteum* and/or *Nymphaea odorata*
Panicum Marsh	Bottom rooted wetland dominated by *Panicum hemitomon.*
Broad-leaf Marsh	Bottom rooted wetland dominated by *Pontederia cordata, Sagittaria lancifolia* and/or *Peltandra virginica*
Linear-leaf Marsh	Bottom rooted wetland dominated by *Cladium jamaicense, Typha latifolia* and/or *Scirpus californicus.*
Scrub-Shrub Swamp	Bottom rooted wetland dominated by *Salix caroliniana* and/or *Myrica cerifera.*
Open Water	Open water or areas only vegetated with submerged aquatic vegetation

rejected to avoid a pronounced edge effect, or placement of part of the sample quadrate in open water. If the desired community type was not intercepted, another heading back toward open water was selected and the process was repeated until the desired floating island community was intercepted.

Species Composition and Biomass

Species richness and biomass measurements were made within a 2 square meter quadrat, 3 m long, 0.66 m wide. Percent cover of herbaceous communities was determined using a maximum 100% coverage and consisted of 10 cover classes. Cover classes were designated as follows, 0 (1-10%), 1 (11-20%), 2 (21-30%), 3 (31-40%), 4 (41-50%), 5 (51-60%), 6 (61-70%), 7 (71-80%), 8 (81-90%) and 9 (91-100%). Scrub-shrub swamp community was divided in to upper and lower canopies each having 100% cover. Canopy partition was at 1.5 m above the substrate surface. Species identification and taxonomic nomenclature was based on Godfrey and Wooten (1979; 1981)

Vegetative species composition was quantified using the following analysis. Importance Value within each community type was determined as the sum of relative frequency and relative coverage for each species. This calculation was conducted as follows:

$$IV_i = RF_i + RC_i$$

Where: IVi = Importance value of species i

RF_i = Relative Frequency of species i

$RF_i = fi / \Sigma f$

f = *frequency of occurrence*

i = *species i*

RC_i = Relative coverage of species i

$$RC_i = Ci / \Sigma C$$

$C = cover\ of\ species$

$i = species\ i$

Species diversity of each community was determined using Simpson's Dominance Index This was calculated using the following equation.

$$D_s = 1 - (\Sigma n_i(n_i - 1) / N(N-1))$$

Where: D_s = Simpsons Dominance Index

n = abundance

N = total abundance

i = species being compared

Community similarity was determined using Sorensen's Community Coefficient (SCC) and Morisita's Community Similarity Index (Brower et al., 1990). The SCC is calculated using the following equation:

$$CC_s = 2c/s_1 + s_2$$

Where: CC_s = Sørensen Coefficient

c = number of species in common to both communities

s = number of species in community 1 and 2, respectively

The Morisitas's Community Similarity Index is calculated using the flowing:

$$I_m = 2\Sigma x_i y_i / (l_1 + l_2) N_1 N_2$$

Where: I_m = Morisita's Community Similarity Index

x_i = abundance of species i in community 1

y_i = abundance of species i in community 1
l_1 = Simpsons Dominance Index for community 1
l_2 = Simpsons Dominance Index for community 2
N_1 = total abundance of community 1
N_2 = total abundance of community 2

To determine if a difference in hydrologic tolerance existed between floating and non-floating communities a hydrologic index was developed. The index of each community was determined by weighting each species wetland indicator status by the coverage of that species at a given sample site. Sample sites within a given community were then averaged producing a community average index of vegetation tolerance to inundation. A value of 1 indicates all species found in that community were obligate wetland species, a value of 2 indicates that the average vegetation tolerance to inundation is that of a facultative wetland species. Species wetland indicator status was determined using the Florida Department of Environmental Protection Wetland Plant Indicator list (FDEP, 1997). This index does not discriminate between inundation tolerance differences within the broad classification of Obligate, Facultative Wet, or Facultative. Because no inundation tolerance classification exists for all species identified in this survey, it was decided that although less sensitive, plant wetland indicator status would be used. Had a more sensitive classification of inundation tolerance existed, statistical differences may have been more significant when analyzing this aspect of the study.

Community biomass was sampled within each quadrat used for species composition. Above the substrate, or in the case of vegetative floating wetlands above the root mat, all biomass within the 2 m^2 sample quadrat was collected. Below-ground biomass was subsampled using two techniques depending on community type. When sampling flotant with no attachment to organic or mineral substrate, four 0.25 m^2 subsamples, were collected randomly within the 2 m^2 quadrat. When sampling organic island flotant, organic marsh flotant or bottom rooted emergent wetlands, three 15 cm diameter cores were randomly collected within the 2 m^2 quadrat and taken to a depth of 2 m or the organic/mineral interface, which ever was shallower. Coring was conducted using a specially designed corer that minimized compaction and allowed for coring of floating substrates (see chapter 3). Below-ground biomass was separated from sediments, washed, then roots and rhizomes were separated. All biomass was dried at 60°C for a minimum of 48 hours. In the case of large rhizomes, drying times were up to 96 hours or until constant weight was established upon successive weighing.

Statistical Analysis

Statistical analysis of species richness, Simpson's Diversity Index, biomass and hydric index were conducted. Welsh ANOVA comparisons were used to analyze variance among community types for each buoyancy component (Sokal and Rohlf, 1969). Welsh ANOVA was used due to uneven sample size among communities. When Welsh analysis indicated a significant ANOVA difference among community means, a Tukey-Kramer Honest Significant Differences Test comparison was used to determine differences among multiple means at the experimental 0.05 % confidence level.

Results

Species Richness

Within the ten communities surveyed, 59 species were identified (Table 2). Community species richness was greatest in floating organic marsh and scrub-shrub swamp communities, both had 32 species. This was followed by floating organic island (29 species), floating vegetative marsh (24 species), and broad-leaf shallow marsh community (23 species of which 9 were floating aquatics or exclusively found on floating substrate). The community with the lowest species richness was floating Bulrush marsh that had 8 species.

Importance of each species varied between communities with the exception of *Hydrocotyle umbellata* (L.) and *Limnobium spongia* (Bosc.) Steud. These two species were ranked in the top five species among 6 and 8 of the 10 communities, respectively. Only *L. spongia* occurred in all ten communities, with *H. umbellata, Lemna minor* L. and *Polygonum densiflorum* Ell. occurring in nine of the communities surveyed. *Panicum hemitomon* Shult. had the greatest importance of any one species within a community with a value of 0.954, occurring in Panicum marshes. All other species had importance values less than 0.5 with the exception of *N. luteum* that had a value of 0.75 in deep marsh communities.

Average site species richness, expressed as number of species, was highest in organic marsh flotant (17.2 ± 3.5 species) and lowest in deep marsh community (4.0 ± 2.4 species) (Figure 2). Average site species

richness was significantly greater ($P<0.05$) in floating organic marshes than in any other communities, with the exception of floating organic islands that were not significantly different. Deep marsh site community species richness was also significantly less than that of floating organic marshes, floating organic islands, shrub swamps and floating vegetative marshes.

Table 2. Species identified in survey of flaoting and emergent vegetative communities of Orange Lake. Importance value of species within the vegetative community in which they were sampled. Importance value based on the sum of relative cover and relative frequency of occurance. Letter under column titled Substrate Association indicates substrate type species was associated with when sampled. "F" indicates floating substrate, "S" indicates Submerged substrate, "FS" indicates species was found on both floating and submerged substrates, "FF" indicates species is free floating at the surface but does not form a mat or tend to support other species, and "A" indicated a submerged Aquatic species.

	Floating Communities					Non-Floating Communities					
	Floating Organic Islands (n=6)	Floating Vegetative Islands (n=6)	Floating Vegetative Marsh (n=6)	*Floaitng Bulrush* Marsh (n=3)	Floating Organic Marsh (n=6)	Deep Marsh (n=6)	*Panicum* Marsh (n=3)	Broad-leaf Shallow Marsh (n=6)	Linear-leaf Shallow Marsh (n = 6)	Shrub Swamp (n=6)	Substrate Association
Subcanopy											
Acer rubrum (L.)					0.016						FS
Alternanthera philoxeroides (Mart.) Groseb.	**0.136**	0.090	0.023		0.032	0.103		0.027	0.036		FS
Amaranthus australis (Gray) Sauer.	0.107						0.075				F
Andropogon glomeratus (Walter) BSP.					0.028						F
Andropogon virginicus L.	0.037										F
Azolla caroliniana Willd.			0.023		0.032	0.103		0.027	0.036		FF
Bidens laevis (L.) BSP.	**0.227**	0.060	0.046	**0.218**	**0.145**						F
Bidens mitis (Michx.) Sherff.	0.021			0.073	0.089						F
Boehmeria cylindrica (L.) Sw.	0.013				0.065			0.027	0.036	0.047	SF
Cicuta mexicana Coult. & Rose.	0.021	0.060	0.069		0.077			0.082		0.024	SF
Cladium jamaicense Crantz.			0.036						0.071	0.061	SF
Cuscuta gronovii Willd.			0.023								F
Cyperus odorata L.	0.043									0.024	SF
Decodon verticillata (L.) Ell.			0.092		**0.169**			0.096	**0.466**	0.089	SF
Eichhornia crassipes (Mart.) Solms.	0.021	0.060									F
Eleocharis baldwinii (Torr.) Chapm.	0.099				0.077			0.027		0.024	F
Erianthus giganteus (Walt.) Muhl.					0.028						F
Eupatorium capillifolium (Lam.) Small.	**0.149**										F
Galium tinctorium L.			0.023		0.032		0.075			0.024	SF
Habenaria repens (L. f.) Caspary.	0.099	0.060	**0.115**	**0.218**	**0.093**		0.075	0.096		0.071	F
Hydrocotyle ranunculoides L. f.	0.064		0.023		0.032		**0.149**		**0.163**	0.071	F
Hydrocotyle umbellata L.	**0.200**	**0.229**	**0.128**	**0.391**	**0.093**	0.103		0.123	0.036	**0.108**	F
Juncus effusus L.	0.021										SF
Lemna sp.	0.021	0.060	0.069		0.065	0.051	0.075	0.027	0.071	0.103	FF
Limnobium spongia (Bosc.) Steud.	0.035	**0.481**	**0.556**	**0.287**	**0.193**	**0.231**	**0.224**	**0.368**	0.036	**0.219**	F
Ludwigia leptocarpa (Nutt.) Hara.	**0.173**				0.016						F
Mikania scandens (L.) Willd.	0.013	0.030			0.065					0.094	SF
Myrica cerifera L.										0.024	SF
Nuphar luteum (L.) Sibth. & Sm.	0.136	0.030	0.071			**0.750**		0.042	**0.219**	0.047	SF
Nymphaea odorata Ait.						**0.314**			**0.132**		SF
Osmunda cinnamomea L.										0.038	S

Table 2 Continued.

	Floating Communities					Non-Floating Communities					
	Floating Organic Islands (n=6)	Floating Vegetative Islands (n=6)	Floating Vegetative Marsh (n=6)	*Floaitng Bulrush* Marsh (n=3)	Floating Organic Marsh (n=6)	Deep Marsh (n=6)	*Panicum* Marsh (n=3)	Broad-leaf Shallow Marsh (n=6)	Linear-leaf Shallow Marsh (n = 6)	Shrub Swamp (n=6)	Substrate Association
Subcanopy											
Panicum hemitomon Shult.	0.043	0.030	0.094		0.061		**0.954**	**0.152**		0.065	SF
Peltandra virginica (L.) Schott & Endl.			0.109				0.075	**0.140**	0.036	**0.192**	SF
Pistia stratiotes L.	0.021										F
Pluchea purpurascens (Sw.) DC.	0.021										F
Polygonum densiflorum Ell.	0.035	**0.259**	0.082	0.073	0.081	0.051	0.075	0.027		0.024	SF
Sagittaria lancifolia L.			0.023		0.044			**0.183**	0.036	0.024	SF
Sagittaria latifolia Willd.	0.043				0.032					0.024	F
Salix caroliniana Michx.										**0.024**	S
Salvinia minima Willd.		0.030	**0.117**	0.073	0.061			0.123	**0.148**	0.024	FF
Sambucus canadensis L.										0.024	S
Scirpus californicus (C. Meyer) Steud.									0.107	0.024	S
Scirpus cubensis Poepp. & Kunth.	0.021	**0.276**	0.082	**0.667**	0.065				0.096		F
Solidago fistulosa Mill.	0.021				0.016					0.024	F
Spirodela polyrhiza (L.) Schleid		0.060	**0.128**		0.049		**0.224**	0.054	0.036	**0.229**	FF
Thelypteris thelypteroides (Michx.) J. Holub					0.085				0.071		SF
Triadenum virginicum (L.) Raf.					0.016					0.024	F
Typha latifolia L.	0.077	0.060			0.032			0.027	0.096		SF
Utricularia fibrosa Walt.		**0.092**						0.027			F
Utricularia foliosa L.											A
Utricularia inflata Walt.						0.071					A
Utricularia macrorhiza LeConte						0.173					A
Wolfiella floridana (J. D. Sm.) Thomps.			0.023		0.032			0.054	0.036	0.061	FF
Woodwardia virginica (L.) J. E. Smith										0.126	S
Canopy											
Myrica cerifera L.										0.384	SF
Salix caaroliniana Michx.										1.616	SF
Community species richness	28	17	22	8	31	10	10	20	20	30	
Number of species found in each community exclusively associated with floating substrates	18	10	12	7	18	4	6	9	6	10	

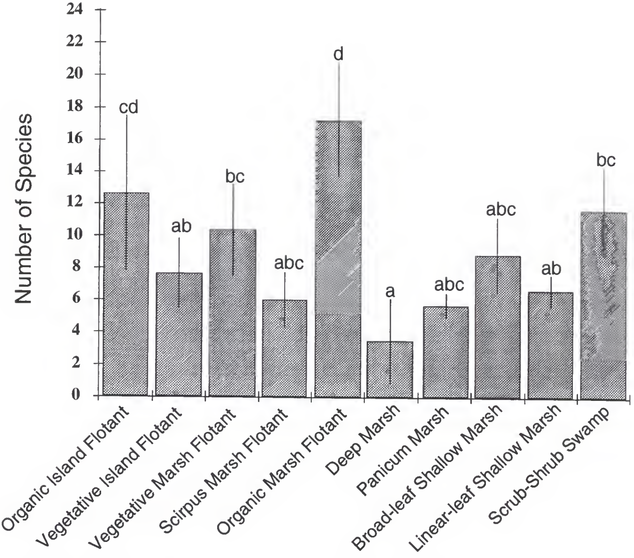


Figure 2. Sample site vegetative species richness (mean ± 1SD). Lower case letters above columns represent significant differences between site average species richness values using Tukey's Honesty Significant Difference test of unequal sample size.

Species Diversity

Simpson's species diversity index for each community type averaged from 0.400 ± 0.266 (deep marsh) to 0.908 ± 0.312 (organic marsh flotant) (Figure 3). With the exception of deep marsh and Panicum marsh, all diversity indices were above 0.500. Floating organic communities and scrub-shrub swamp communities all had values above 0.800. Significantly greater diversities were found on floating organic communities than floating vegetative island, linear-leaf shallow marsh, deep marsh or Panicum marsh communities. Deep marsh and Panicum marsh communities had significantly lower species diversity values than floating vegetative marsh, or broad-leaf shallow marshes.

Vegetative Community Similarity

Comparison between vegetative species composition using Sorensens Coefficient of community similarity indicate floating vegetative marshes and broad leaf shallow marshes had the greatest number of species in common (Table 3). Communities with the least number of species in common occurred between floating bulrush marshes and scrub-shrub swamp communities. Similarity differences between communities using Morisita's Index, which takes species abundance into account, showed similar differences. Using Morisita's Index, communities with the greatest similarity were floating vegetative islands and floating vegetative marshes (88% similarity)(Table 3). Similarity between floating vegetative marsh and broad-leaf shallow marsh were also close with a value of 80%. Communities of lowest similarity according to Morisita's index were deep marsh and *Panicum* marsh (1%). When comparing among all communities, deep marshes and Panicum marshes were the most unique with respect to species composition. This is based on the finding that species assemblage and abundance of these communities had less than a 25% similarity to any other communities surveyed.

Vegetative Species Habitat Association

One reason for the high similarity between floating vegetative marshes and broad-leaf shallow marshes, was that although broad-leaf marshes were dominated by bottom rooted emergence, there was often a well established floating vegetative mat associated with these sites. Conversely, in areas dominated by floating macrophytes, and therefore classified as vegetative marsh flotant, there was often bottom rooted emergent species present protruding up through the vegetative mat. To evaluate the number of species associated with floating vs. non floating substrates regardless of the community classification in which they were sampled, all species identified were secondarily classified based on the habitat they were associated with (Table 2). The five habitat classifications identified were, "F" exclusively found on floating substrates, "S" exclusively found on submerged substrates, "SF" found on both floating and submerged substrates, "FF" free floating aquatic species (ones which were not bottom rooted, but were also not mat forming), and "A" submerged aquatic species. Using this classification, 39% of all species identified in this survey were found exclusively on floating substrates, 10% were exclusively found on submerged substrate, and 37% were found on both floating and submerged substrates. In addition, up to 60% of the species richness found at emergent marsh community sites were not bottom rooted species, but instead only found on floating portions of the site (Table 2).

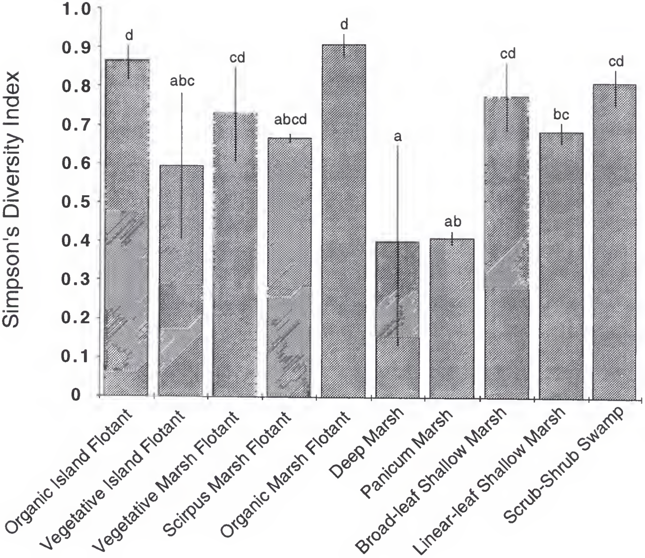


Figure 3. Average site Simpson's Diversity Index (mean ± 1SD). Lowercase letters above columns indicate significant difference ($\alpha = 0.10$) using Tukey's Honesty Difference Test of unequal sample size.

Table 3. Values represent two measures of community similarity. Values in upper right half of rectangle were calculated using Sorensen's Coefficient of community similarity. Values in lower left half of rectangle were calculated using Morisitas Index of communitiy similarity.

Sørensen's Coefficient of community similarity

floating organic island	0.596	0.491	0.189	0.688	0.350	0.359	0.500	0.360	0.525
0.232	floating vegetative island	0.619	0.500	0.600	0.483	0.357	0.683	0.462	0.560
0.168	0.877	floating vegetative marsh	0.437	0.679	0.457	0.529	0.765	0.711	0.607
0.205	0.611	0.309	floating Bulrush marsh	0.400	0.315	0.333	0.322	0.276	0.250
0.492	0.521	0.518	0.681	floating organic marsh	0.326	0.381	0.655	0.566	0.656
0.249	0.135	0.207	0.031	0.059	deep marsh	0.286	0.667	0.437	0.279
0.095	0.068	0.145	0.015	0.096	0.011	Panicum marsh	0.424	0.476	0.429
0.276	0.668	0.796	0.199	0.635	0.148	0.193	broad-leaf shallow marsh	0.682	0.655
0.127	0.230	0.295	0.108	0.225	0.210	0.014	0.278	linear-leaf shallow marsh	0.566
0.185	0.477	0.622	0.145	0.556	0.097	0.161	0.630	0.284	shrub swamp

Morisita's Index of community similarity

Community Inundation Tolerance

Community hydric index values ranged from 1.01 ± 0.02 (deep marsh) to 1.41 ± 0.22 (floating organic islands). Floating organic islands had a significantly higher hydric indices than that of all emergent wetlands, floating vegetative communities, and floating organic mashes (Figure 4). It was also noted that site index value deviation around the mean increased among all floating communities relative to non-floating communities, with the exception of floating vegetative marshes. This did not appear to be the result of a single site outlier within the average, but instead a broader range of values within floating wetland community sites as compared to sites of non-floating communities.

Vegetative Biomass

Panicum hemitomon marshes had the greatest standing biomass averaging 4.27 ± 1.07 kg dw m^{-2}. This was significantly greater than all other communities with the exception of linear leaf shallow marshes (Figure 5). The lowest standing biomass was found in floating Bulrush marshes that averaged 0.92 ± 0.34 kg dw m^{-2}. It should be noted, however, that although scrub-shrub swamp communities appeared to have low standing biomass values, this value only accounts for above-ground biomass of the subcanopy and all biomass below-ground. If above-ground canopy biomass had been collected, total biomass for shrub swamps would likely have been greater.

Separating standing biomass into above and below-ground components, *P. hemitomon* still had a significantly greater above-ground standing biomass than all other communities (Figure 6). There is also significantly greater above-ground standing biomass of broad-leaf and linear-leaf shallow marshes than that of floating vegetative island and deep marsh communities. However, the significantly greater standing biomass

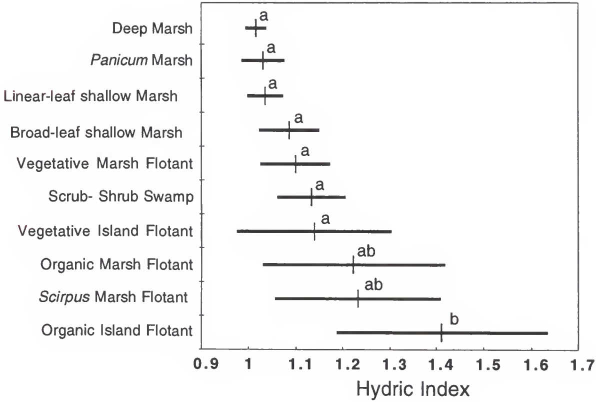


Figure 4. Index of vegetative community hydric status (mean ± 1SD). Index ranges from 1.00, 100% obligate wetland species to 4.00, 100% upland species. Community hydric status determined by average of species wetland indicator values weighted by species coverage at each sample site. Species wetland indicator status determined using national plant indicator list (Sabine, 1992). Lowercase letters designate significant differences ($\alpha = 0.05$) using Tukey's Honesty Significant Difference test with unequal sample sizes.

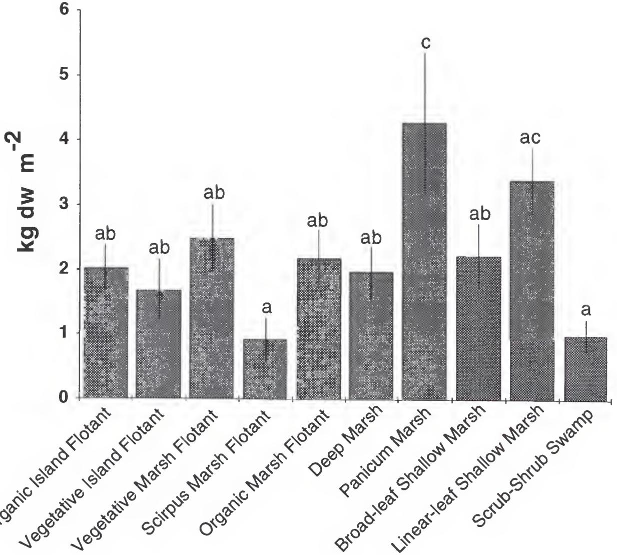


Figure 5. Total community standing biomass (mean ± SE). Letters signify significant differences in standing biomass between communities using Tukey's Honesy Significant Difference test of unequal sample sizes.

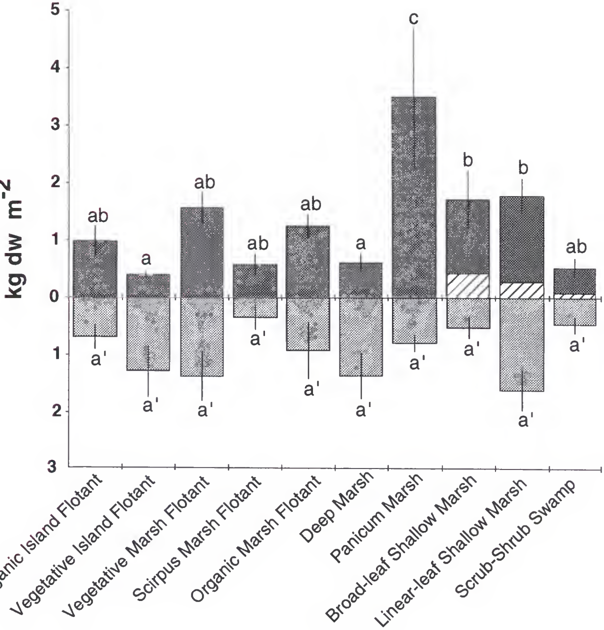


Figure 6. Above-ground (light shading) and below-ground (dark shading) community standing biomass (mean ± SE). Diagonal pattern in broad-leaf, linear-leaf and shrub swamp communities denotes portion of above-ground biomass contributed by floating species. Letters signify significant differences in standing biomass between communities using Tukey's Honesy Significant Difference test of unequal sample sizes.

of broad-leaf shallow marshes and linear-leafed shallow marshes is due to biomass contributions from vegetative floating mats found within the sample quadrat of these communities. As indicated earlier, vegetative floating marshes and shallow emergent marshes are often found intermixed with only slight shifts in dominant species determining community type. If floating biomass is removed from the above-ground total of these emergent communities, there is no longer a statistically significant difference between these two shallow marsh communities and all other communities with the exception of *P. hemitomon* marshes.

Discussion

Species Composition

Presence of floating wetlands, especially that of organic floating wetlands, can significantly increase species richness of the Orange Lake ecosystem. It was found that 23 of the 59 species identified occurred exclusively on floating substrate, with eight of these found only on organic floating substrate. This would indicate floating wetlands provide a unique habitat type when compared to the five emergent wetland communities surveyed. It is hypothesized that initial formation that exposes new substrate and subsequent differences in hydropattern on floating wetlands provide this unique habitat type.

One obvious explanation for higher species richness and unique habitat found on floating wetlands is that formation of floating substrate provides conditions for colonization by pioneer species and germination of seedbank species requiring absence of inundation. Such species are likely adapted for colonization of disturbed sites with low competition, similar to those conditions found during a low water event that exposes bottom sediments (Pederson and Smith, 1988; Gerritsen and Greening, 1989; van der Valk, 1981). Formation of organic flotant essentially mimics a low water event by raising the bottom sediment to the surface creating varying degrees of sediment dewatering depending upon the buoyancy of the floating substrate. This newly exposed substrate allows for species to become established that in the absence of a low water event may not be present or be as prominent during mean or high water conditions. Had this survey been conducted during a drought year, when areas of bottom substrate were exposed, many of the species found exclusively on floating substrates may have occurred on these early successional areas of newly exposed bottom. The formation of floating wetlands and habitat that is provided to these pioneer and early successional species may be a significant influence on the seedbank characteristics of lake bottom sediments maintaining annual and pioneer species within the seedbank between periods of low water. This may be especially true if modification of lake hydrology reduces the frequency of low water events. A similar function of flotant communities was proposed in the Okefenokee Swamp to maintain annuals and short lived perennials seeds in the seed bank (Glasser, 1986).

Hydropattern difference between floating and non-floating sites may also be sufficiently different to provide unique habitat, especially after secondary colonization reduces the uniqueness of these communities with respect to early succession. Specific to Orange Lake, seasonal increases in water level typically occur beginning in June, peak in September and October, and then begin to decline (SJRWMD, 1998). In contrast, floating wetlands having decomposition gases as their principal component of buoyancy typically form when water temperatures are increasing. As a result, as water levels become deeper in bottom rooted emergent communities, formation of organic flotant communities increases, exposure of sediments above the water surface should be near their maximum. Therefore, the timing of hydropattern would appear to be significantly shifted as a result of flotant formation especially that of organic flotant and may contribute to the selection of species that are exclusive to these substrates.

Flotant substrate has also been shown to persist from days to tens of years. In the case of older floating wetlands, successional stages have been described by Glasser (1986) representing changes in dominant species and eventual colonization by woody shrubs and trees. In the case of bottom rooted emergent marshes, vegetative succession is often arrested at any elevation along the hydrologic gradient until sediment accumulation causes a change in hydrarch succession. These changes occurring over extended periods of time and interspersed by rapid changes in community type during periods of extreme high or low water. Flotant, however, especially newly formed organic flotant which remain floating for a significant duration may allow for multiple sere stages of succession to occur over relatively short periods of time. Until buoyancy of the floating substrate is compromised, successional series similar to that of an extended low water event should continue. Because formation of floating substrates occurs seasonally, a wide range of successional seres can occur simultaneously, representative of varying durations since the flotant originally formed. This could also explain the large species richness of these communities in that sampling of multiple islands may actually be similar to sampling the same site over multiple years of succession. If floating wetlands could actually be separated into several discrete seres, lumping these seres into a single community type would result in a larger number of species. In most cases emergent wetland communities surveyed represent a single sere that is temporarily arrested as a result of hydropattern.

Therefore comparing a single vs. multiple seres may actually explain the species richness results identified and simply be an artifact of the experimental design. Although this indicates a unique characteristic flotant may express in communities in which they form.

Lastly, buoyancy on floating substrates may allow for microtopographic relief on these communities to be more effectively colonized than that of microtopographic relief in emergent marsh communities. On floating wetlands elevation differences in microtopography were often expressed above and below the water surface. This distribution increases the overall range of hydrologic habitat that can be colonized on floating wetlands and may explain the greater species diversity values occurring on floating organic wetlands as compared to emergent marsh communities. Microtopographic relief also occurred in emergent marsh communities, however, with the exception of scrub-shrub swamp communities, depth of inundation did not allow this variation in elevation to be expressed. Therefore, potential habitat heterogeneity related to hydropattern did not result in increased species richness. Water depths within scrub-shrub swamp communities were the lowest of all emergent wetland communities and therefore were likely the reason why species diversity and species richness were so high in this community.

Standing Biomass

With the exception of *P. hemitomon* dominated shallow marshes, there were no significant difference in total biomass between communities surveyed. However, when separating below-ground and above-ground total biomass, we did see significant difference between shallow marshes, floating vegetative islands and deep marsh communities. Bayley (1985) indicated that water level contributed significantly to productivity with reduction in inundation stress increasing productivity of similar plant communities. However, in another study on the effect of floating substrate and nutrient availability, response to inundation was species specific and potentially regulated by nutrient limitation induced by floating substrate (Clark, 1999). Although formation of floating substrate would appear to reduce stress of inundation and therefore stimulate productivity, it is possible that nutrients may become limiting on floating substrate especially in vegetative floating communities. Several studies indicate tight nutrient cycles within vegetative mats (Estaves et al., 1996), and dependence upon available water column nutrients for productivity (Clark, 1999). This may indicate that although inundation stresses may be reduced due to floatation, if floatation also results in nutrient limitation, biomass production will not necessarily increase under floating conditions.

Inundation Tolerance

Formation of organic island flotant can result in vegetative habitat that is lower in inundation stress. It also appears that floating organic marshes and floating organic islands provide sufficiently reduced stress at some sites to allow for colonization by more mesic species. It is not surprising that floating wetlands provide significantly different hydrologic conditions relative to open water habitat and allow for establishment of obligate wetlands species. However, colonization by species that would otherwise be restricted to the uppermost boundary of the wetland ecotone is significant. Although hydric index values calculated for all communities surveyed would be considered wetlands according to Florida State statutes, the significant shift in hydric index on organic flotant indicate a terrestrialization of these particular locations of the lake. The hydric index developed for this survey is also very conservative with respect to identifying a shift in inundation tolerance. This index only measures species tolerance to general wetland inundation criteria. A more representative index would evaluate species specific inundation tolerances to determine the distribution of species along a depth gradient within a wetland. Had this been available, a much greater shift in inundation tolerance of species found on floating wetland communities would likely have been evident.

Conclusion

This survey indicates a significant influence of floating wetlands on the vegetative composition of Orange Lake. Change in type or character of floating community may have significant effects on species richness, abundance, and standing biomass of wetlands within the lake ecosystem. Although specific mechanisms affecting hydropattern and possibly nutrient availability will require further investigation, results suggest a significant effect of floating substrate formation on these environmental variables. For these reasons implications of hydrologic changes to Orange Lake and their implication on formation of floating wetlands should be considered.

Of broader application is the significance of this information with respect to hydrarch succession and how terrestrialization of open water and emergent marsh communities might indicate later successional stages of aquatic ecosystems. Accumulation of organic material and bottom up sedimentation will eventually result in the conversion of open water areas into emergent marsh communities. The rate of this process depends on rates of carbon production and decomposition that may take thousands of years to reach relative equilibrium. However, formation of floating wetland communities, especially that of organic floating wetlands may represent a particular stage of lake development at which point sufficient organic sediment have accumulated to trap decomposition gases and form floating substrates. Vegetation, which then becomes established, is less hydrophytic even though complete in-filling has not yet occurred.

CHAPTER 3
LOW COMPRESSION CORER AND SUBSURFACE VIEWER FOR SAMPLING FLOATING WETLANDS

Introduction

Conditions found on floating wetlands present unique issues for sampling of sediments and vertical profile characterization. Sediment coring is problematic due to the extreme differences in bulk density found between the root mat, sediments and open water zone below the mat. Vertical profile characterization is difficult since subsurface characteristics, such as bottom of the floating mat, depth of bottom sediment, and features of the free-water zone below the mat are inaccessible without excessive disturbance. In 1996-97, an investigation of floating and non-floating wetland communities on Orange Lake, north central Florida prompted the development of two sampling devices that would facilitate sampling of these communities. Specific objectives of this study and therefore design parameters of the two sampling devices presented here, included vertical profile characterization, determination of buoyancy budgets and description of peat stratigraphy. Communities to be sampled ranged from organic marsh flotant and shrub swamps, to open water unconsolidated lake bottom sediments. This range of sampling needs and diversity of community structure provided design challenges as well as a wide range of conditions to test the effectiveness of the corer and viewing device designs developed.

Sampling sediments on floating communities is complicated by the lack of resistance provided by sediments floating in the water column. Unlike more typical lake sediments and wetland soils, free water below the root mat of floating communities does not resist the downward force of conventional tube coring devices with sharpened leading edge. Preliminary cores collected using the conventional technique usually resulted in pushing the mat below the water surface, or pushing roots and substrate through the mat into the water column below. A similar situation can occur in bottom substrates that are more consolidated at the surface, due to roots, litter or surface compaction. During coring of these sediments, surface sediment and roots can be pushed down deeper in the profile, resulting in core compaction, redistribution of features and lateral loss of sediments. Previous efforts to overcome this problem have addressed several design parameters often found in modern cylindrical sediment coring devices. One parameter is to increase the core diameter. This minimizes the cutting surface as a percentage of the area and therefore decreases liner friction relative to core volume (Clymo, 1988). Sharpening the leading edge of the corer minimizes the amount of pressure needed to cut through roots and fibric sediments. One design has even used a replaceable razor blade along the leading edge to optimize this feature (Hargis and Twilley, 1994). The most effective addition to coring tube designs is the addition of a piston or plunger inside the tube to provide a slight vacuum and prevent sediment compaction. This helps draw the sediment core up into the liner (Fisher et al., 1992). These improvements, especially when optimized and combined, can increase the effectiveness of the coring device to within sufficient parameters for most coring needs. However, the underlying requirement that cutting and movement of sediment into the core is mainly dependent upon vertical resistance still make these coring designs ineffective on floating substrate communities.

Only one coring design noted in the literature that was designed for sampling of peat utilized a toothed cutting surface (Clymo, 1988). This design consisted of rounded teeth along the leading edged that were sharpened to a thin material thickness. This design created a slight lateral cutting force on roots and peat as fibers came in contact with each tooth. This design was also tested on floating substrates in Orange Lake, but although performance was improved over other coring designs, it was unable to provide low disturbance samples from cores with large roots within the sediment matrix.

The corer design adopted overcomes issues of vertical resistance by creating a scissors like cutting surface that is not dependent upon sediment resistance to sever roots and fibric sediment. Instead, a rotary motion of the coring device pinches roots and fibric sediments between two cutting surfaces. Pressure between the cutting surfaces easily reaches the break threshold of roots and fiber while requiring minimal resistance from the surrounding sediments. Rotary disturbance of the core is eliminated by maintaining the inner core liner stationary while rotating a set of cutting teeth around the outside. This coring technique reduced the vertical pressure required to penetrate the sediments and thereby did not submerge floating mats or significantly compress subsurface sediments during coring activities.

Subsurface Viewer

Visualization of undisturbed features within and below floating sediments was also desired in this study to document the structure of these communities. It is possible to cut sections of floating communities apart, extract them from the water column and visualize them at the surface. However, this technique is likely to present a false image of root orientation below the mat, below mat water clarity and an accurate thickness of the floating substrate. A similar inaccessibility issue occurs in the study of terrestrial below-ground vegetative biomass. Efforts to address these problems in terrestrial environments have used rhizotrons composed of glass faced growth chambers (Arkin et al., 1978) or glass or Plexiglas windows inserted into the soil profile allowing observation of roots growing at the glass/soil interface (Böhm, 1979). One technique was to insert a clear glass tube into the sediment near a newly planted crop and view root development around the glass tube with a mirror affixed at a 45° angle to a rod with light source (Böhm, 1974). Böhm's method was modified to visualize subsurface features of floating communities, with the exception that transparent tubes were not set permanently within the sediment/root matrix, but could be inserted, extracted and relocated as needed. In addition, fine detail of root growth was not desired at this time, only gross features of the profile were investigated, therefore disturbance due to insertion of the instrument was considered negligible for purposed of this study.

Design and Procedures

Corer Design

The corer design has four principal parts; cutting head, housing, core liner and piston. The cutting end of the corer consists of two components, the outer head, and the stationary inner head (Figure 1). The outer head is 15.90 cm ID, 17.25 OD at widest point, and 20 cm high. The bottom end of the outer head is beveled at a 5° angle and has five slots, 1.25 cm wide, 0.35 cm deep, and 2.5 cm long. These recesses were spaced equidistant around the circumference of the outer cutting head. In each of these slots a cutting tooth is positioned and kept in place by a single #8 flat head machine screw set

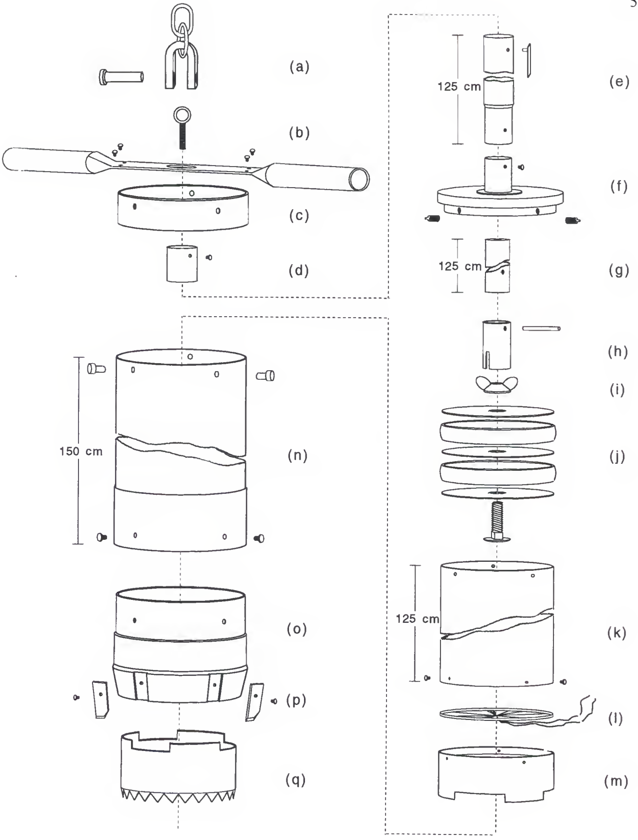


Figure 1. Corer components, scale 1:4 except where noted. a)shackle and chain to A frame, b) eye bolt, c) turner assembly, d) keeper, e)holder/extractor pipe, f)liner cap and pin plungers, g)piston rod, h) wing nut turner, i) piston wing nut, j)piston assembly, k) core liner, l) closure shoot, m) liner collar, n) corer housing, o) outer cutting head, p) cutting teeth, q) inner cutting head.

with threadlock compound (Locktite #222-21) and ground flush to the inner radius. Each tooth was constructed of C-2 grade carbide steel. Cutting tooth dimensions are 3.5 cm long, 1.23 cm wide, and 0.4 cm thick. Each tooth is approximately rectangular with a slight narrowing at the bottom end to a width of 1.0 cm. The leading and bottom edges of each tooth were sharpened to a razor edge. Along the inner surface of the outer head, 7 cm back from the bottom edge a 0.5 cm tall by 0.4 cm deep groove is cut. This groove is a recess for Teflon rods/bearings, 0.5 cm in diameter, that pass through the inner head and ride in the grove of the outer head (Figure 2). This bearing maintains the positioning of the inner cutting head relative to the outer cutting head so that the cutting surface tolerance is maintained.

The outer head is attached to a collar recess in one section of the corer housing. Each corer housing was constructed of 0.16 cm thick 304 stainless steel. Each section has an inside diameter of 16.6 cm and is 125 cm long. At one end of each corer housing section, a collar recess 7.5 cm deep with 17 cm ID, allows connection of housing sections. Up to four 125 cm long housing sections could be attached by fitting the sections together and securing them with #10 machine screws mated to threaded holes in the housing wall.

Dimensions of the inner cutting head are 15.5 cm ID, 15.8 cm OD and, 15 cm high. The inner cutting head fits snugly inside the outer cutting head with a 0.05 cm gap tolerance between the two heads. Twenty four teeth are cut into the inner head 1.2 cm deep and 2.0 cm apart on center. Tooth surface of the inner head is tapered at a 5° angle from outside to inside to match that of the outer head cutting teeth. The tips of the outer cutting teeth were set back 0.2 cm from the tip of the stationary teeth of the inner head. This allows an object to be stabilized by the stationary inner head teeth before the outer

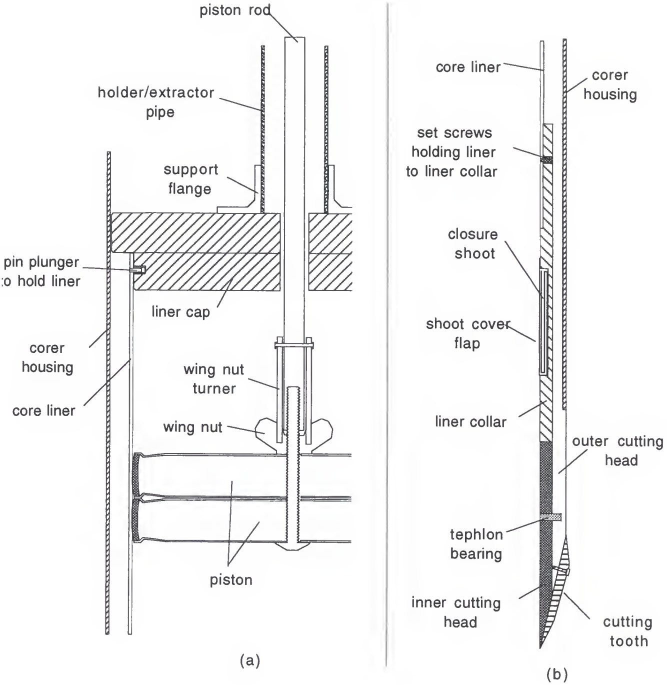


Figure 2 . Cross section of corer through a) piston and liner cap, and b) cutting head and liner collar. Components drawn to scale.

head cutting teeth encounter the object. The top rim of the inner head was machined into a gear with three notched recesses. These recesses match cogs in the liner collar when the liner is loaded into the core housing.

Core liners were constructed of 15.24 cm ID aluminum irrigation pipe that was 0.15 cm thick. Each liner was cut to a length of 100 cm. At both ends of the liner, three holes were drilled equidistant around the circumference. At the bottom end, the liner collar was attached to the outside of the core liner using #8 machine screws. Dimensions of the liner collar were 15.8 cm OD, 15.5 cm ID and 7 cm high. Cog recesses were 1 cm below the liner collar rim. The liner collar locks into the recesses notched in the inner cutting head described previously. On the inner surface of the liner collar, there was a 0.15 cm deep by 3 cm tall recess. In this recess a cloth closure shoot was folded and tucked behind a vinyl flap. The closure shoot was constructed of rip stop nylon in the shape of a collar, 9 cm tall and 15.5 cm in diameter. Along one edge of the closure shoot, fabric was sewn to form a tube through which a nylon line was threaded. The two ends of the nylon line were passed through grooves in the liner collar between the core liner and the liner collar. When the shoot lines were pulled, the shoot would close in a manner similar to an iris diaphragm. This effectively closed off the 15.25 cm diameter opening at the end of the core liner.

At the top end of the liner, a liner cap was attached using three 0.95 cm diameter by 2.54 cm long standard spring plungers that had 0.5 cm diameter center pins. The liner cap was constructed of two circular slabs of resin fiber composite, 1.75 cm thick bolted together. The bottom slab fit inside the liner, the top slab was slightly larger in diameter than the liner and rested on top of the liner. The liner cap thereby stabilized and centered the top of the liner within the outer housing. A 1.25 cm diameter hole was cut in the center of the liner cap to allow the piston rod to pass through.

The piston is constructed of three aluminum plates 0.5 cm thick by 15 cm in diameter interspersed by rubber gaskets. Rubber gaskets are 1.5 cm high, by 0.75 cm thick by 15 cm in diameter with a slight convex arc, making the center slightly larger in diameter than the top or bottom of each rubber gasket. Connecting aluminum plates and rubber gaskets is a 1.25 cm diameter by 6 cm long carriage bolt, with a wing-nut threaded at the top end. Piston rods were constructed of 1.6 cm diameter aluminum rod in 125 cm length sections. The bottom most piston rod connected to the piston by threading onto the remaining thread of the carriage bolt above the wing nut. Additional piston rods could be attached by male/female thread connections between each rod section. At the bottom of the piston rod, adjacent to the wing nut, a 5.0 cm long wing nut turner, 2.0 cm ID and 3.0 cm OD, was attached. The wing-nut turner was free to move up and down depending upon orientation of the corer, but can not rotate on the piston rod unless the piston rod is turned. At the bottom of the wing-nut turner, two slots are cut allowing the pipe to fit over the two wings of the wing-nut at the top of the piston. Once the piston rod is threaded to the piston, the wing-nut turner is slipped over the wing nut at the top of the piston. If the piston rod is turned, the wing nut also turns, compressing the piston and expanding the rubber gaskets of the piston. This locks the piston inside the core liner.

During coring, the piston rod was held in position by a chain that was suspended from a seven foot A frame (Figure 3). A 1.0 cm diameter, 10 cm long eye bolt is threaded into the top of the piston rod. This is attached to a chain secured at the top of the A frame using a 1.25 cm screw pin shackle. The A frame is erected on site and supported on a wooden platform.

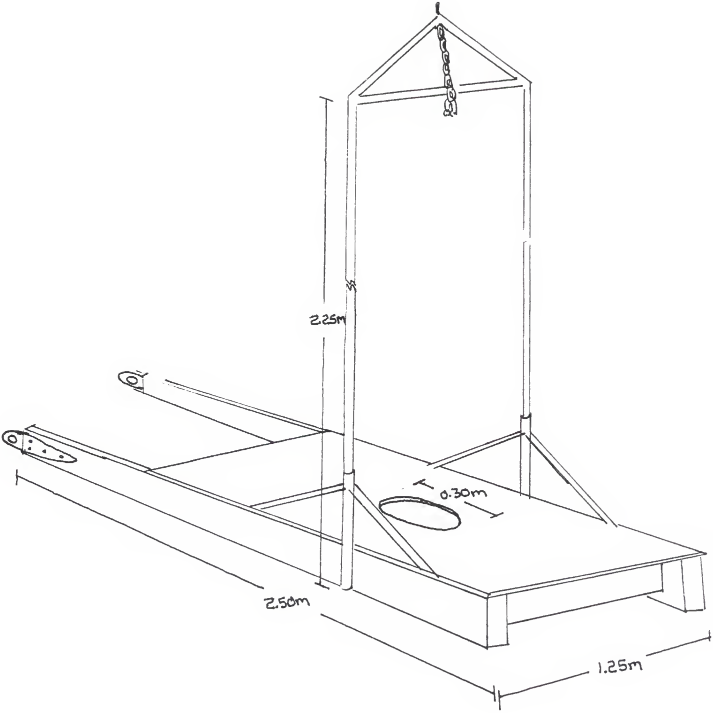
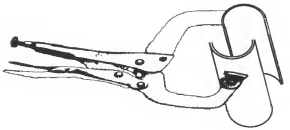


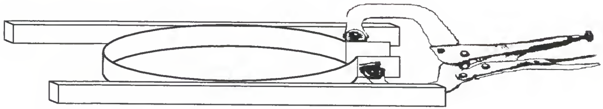
Figure 3. Coring platform and A frame support. Coring platform was semi permanently attached to the deployment vessel, but could be easily taken off of the vessel in the field if the platform needed to be hand carried into a site. The A frame was transported disassembled and erected in the platform stanchion after other sampling efforts were completed at the site.

At the top of the liner cap, a bracket was attached to connect the first section of holder/extraction pipe to the liner and liner cap. Each holder/extractor pipe is 2.54 cm ID, 0.16 cm thick steel pipe, cut in 125 cm long sections. Sections had slightly smaller diameter measurements at one end forming a male/female slip connection. Connection between sections are secured using a spring steel flange with a 0.6 cm diameter pin, 0.25 cm long, that fit in aligned holes drilled in each of the holder/extractor sections. The spring steel flange allowed for quick connect and release of sections during loading and extraction of core liner from the core housing.

The turner handle, used to rotate the outer housing, was fabricated from 3.0 cm OD aluminum alloy, flattened in the center. The handle was attached to a steel collar 16.6 cm OD and 0.5 cm high. The collar fit snugly inside the upper most section of corer housing and was secured using three 0.5 cm diameter stainless steel pins pushed through aligned holes. To hold the holder/extractor pipe from turning, and thereby the liner and inner cutting head, during operation, a pair of vice grips were modified by attaching a half round section of pipe, 2.75 cm OD, to each end of the vice grips (Figure 4a). On the inner surface of the half round pipe, course sandpaper was attached for greater friction that helped prevent the holder/extractor pipe from spinning during coring operations. A second pair of vice grips, were modified to hold the core housing during liner loading and extraction (Figure 4b). The ends of these vice grips were modified by attaching a band of stainless steel, 2.0 cm high, and 0.15 cm thick. When the vice grips were open the stainless steel band had a radius of 19 cm, wide enough for the corer housing to move unrestricted within the band. When the vice grips were closed, the diameter decreased to approximately 17 cm. This was sufficient to securely hold the corer housing from slipping through the band. Along opposite sides of the band, two aluminum tubes with



(a)



(b)

Figure 4. Modified vice grips for corer operation, scale 1:2.5. a) used to hold holder/extractor pipe that keeps inner cutting head stationary during coring. b) clamp used to hold corer housing during liner loading and extraction procedures.

dimensions 1.5 cm by 1.5 cm by 35 cm long were attached. Length of the tubing was sufficient to span the hole in the coring platform and when the vice grips were tightened around the corer housing, these tubes prevented the corer housing and vice grips from passing through the hole in the platform.

Corer Deployment Methods

The corer was deployed in the field using four different methodologies (Figure 5). The most common method was to securing the coring platform and a frame to the bow of an air boat. The platform was hinged at the base of the airboat operator platform and supported at the platform tip by a 55 gallon drum placed under the platform after other sampling activities at the coring site were completed. The 55-gallon drum provided additional support for the coring platform and considerably increased stability of the piston during coring operations. Hinging the platform at the base of the operator platform also stabilized the platform by distributing platform weight at the center of the airboat and not exclusively at the bow. Open water deployment of the corer required the use of Jon boats due to the inherent instability of a stationary airboat in open water conditions. The two riggings for deployment of the platform using Jon boats was to use two small Jon boats and suspend the platform between the two, or deploy the platform off one side supporting the end with the 55-gallon drum similar to that of the airboat. The last method used was to deploy the platform in areas inaccessible by the airboat. These included dryer sites and shrub-scrub swamps. Deployment in these areas required detaching the platform from the airboat and manually carrying it into the sampling site. Each of these methods provided suitably stable platforms for deployment of the corer.

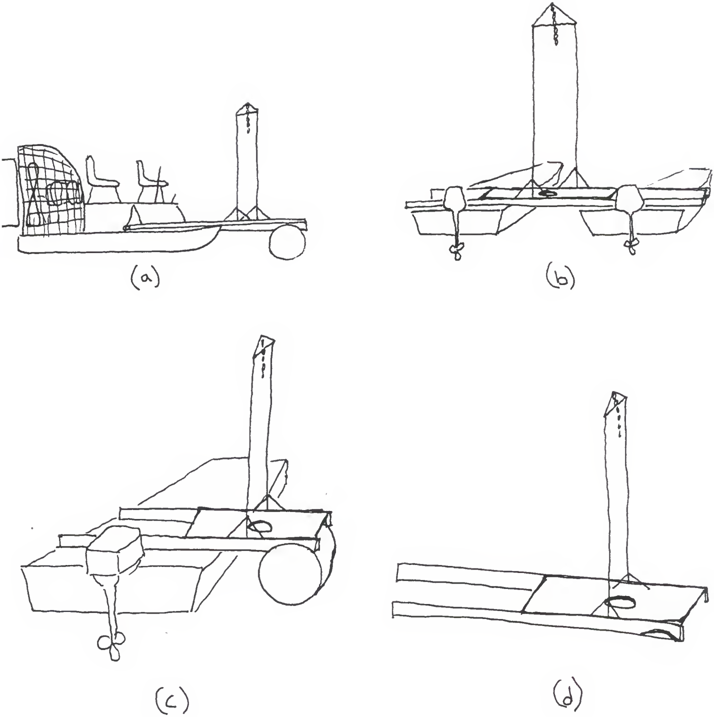


Figure 5. Corer deployment methods used on Orange Lake. a) Deployment off the bow of an airboat, b) catamaran deployment between two small Jon boats, c) outrigger deployment off one side of a large Jon boat, and d) hand carried deployment into areas inaccessible by airboat.

Coring Procedure

Preparation of liner and coring procedure for each one meter core liner extraction was as follows. The collar section is first attached to the bottom end of a core liner using three inset screws. The closure shoot is neatly folded in the slight recess in the collar and tucked behind the vinyl cover flap. Shoot pull lines were led between the liner collar and the core liner, taped using masking tape to the outside of the core liner, and pulled slightly taught so the lines would lay flat. The liner cap is attached to the top of the core liner by depressing plunger pins and aligning holes to lock liner cap in place. Pull lines of the shoot were then laid in two groves cut in the liner cap and taped to the holder/extractor pipe. Next the piston is threaded onto the piston rod, and the piston rod passed through the hole in the liner cap and seated snugly just inside the liner collar. This assembly is now ready to load into the core housing.

Prior to coring, the core housing with cutting head attached is positioned through the opening in the coring platform and secured using the housing clamp. This clamp prevents the housing from falling through the hole and is used to secure the housing at various stages during set up and extraction. Once the housing is secure, the liner assemblage is lowered into the outer housing until the liner collar rests on the inner head. To make sure cogs in liner collar seat in recesses of inner head, a slight rotation of the liner eventually causes the liner to drop about 1 cm, interlocking the inner cutting head and the liner collar/liner assemble. Next a keeper is clamped onto the holding/extractor pipe approximately 0.5 cm below the rim at the top of the housing. The turning handle is fitted to the top of the housing and rests on the keeper. The liner assemblage and housing are now interlocked, the keeper maintaining the linkage between recess and cog of the inner cutting head and liner assemble, respectively. The coring apparatus is then lowered

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through the hole in the coring platform until the piston (recessed about 2 cm behind the cutting teeth) is at the depth to begin coring. The housing clamp was tightened to hold the coring apparatus while the piston was secured to the A frame. An eyebolt was threaded into the piston rod extending above the holding pipe and attached to a chain secured to the A frame. Chain and eyebolt are attached using a shackle and made taught to begin the coring operation. The last step prior to coring is to tighten the modified vice grips onto the holder/extractor pipe to keep the liner, and therefore the inner cutting head, from rotating as the outer housing is rotated. When each of these steps is completed the housing clamp is released and coring commences.

During the coring procedure the housing is rotated clockwise with minimal downward pressure. In soft sediments some upward support is used to reduce the rate of vertical movement. A maximum of one revolution per 2.5 cm vertical penetration is considered optimal during the coring processes. This relates to a cutting action between the outer head teeth and the inner head teeth that occurs every 0.5 cm of vertical penetration. If any significant resistance was encountered, the rate of vertical penetration was slowed to cut through the resistance and not force the resistance deeper into the sediments.

Once a meter depth had been cored, the liner was extracted. First the housing clamp was secured, thus maintaining the position of the outer housing in the core hole. Next the clamp holding the holder/extractor pipe was allowed to rotate while the housing was rotated. This action would sheer the sediments inside the core from the surrounding sediment at the end of the corer. Next the piston rod was detached from the A frame and the piston rod rotated clockwise to tighten the wing nut on top of the piston compressing the piston and locking the piston in place in the core liner. The turner handle was then removed form the outer housing. Next, tension was placed on the closure shoot string and the liner assemblage was slowly lifted to disengage the liner collar from the inner cutting head. In unconsolidated sediments or in open water below floating communities the shoot would pull closed immediately upon application of tension usually providing a water tight seal at the bottom of the core. In peat or more consolidated sediments, the shoot would not often close completely, however, tension on the shoot would create a slight restriction in the diameter at the end of the corer that prevented sediments from slipping free upon retrieval. Once the liner was separated from the corer housing (approximately 10 cm vertical distance), suction created by liner extraction was quickly neutralized by water rushing between the liner and the inside of the core housing. This considerably reduced the amount of force required for liner extraction from the sediment when compared to other methods having to compensate for a full meter of vacuum created by liner extraction. The liner assemblage could then be easily pulled from the outer housing and inverted on the coring platform. Once inverted, the collar was removed and a cap secured at the end of the core. The core was then righted and the liner cap and piston removed. A second cap was then placed on the top of the core and the core maintained in an upright position using specially designed racks for transport.

After the first meter of core, additional one meter cores could be collected by extending the core housing, holder pipe and piston rod by adding sections of these components as needed. The maximum length core collected in Orange Lake was 4.10 m. This was the maximum extent of our coring capabilities both in length of equipment and ability to overcome the peat friction along the outside of the core housing during rotation.

Once sediment cores have been extracted to the desired depth, the core housing is pulled up, securing at stages to disassemble each 125-cm section. If mineral deposits are encountered, especially when coring to the organic/mineral interface, a through cleaning of the inner and outer heads by rotating in water is necessary to prevent jamming and excessive wear on the teeth and Teflon bearings within the cutting head.

Subsurface Viewer Design

Submerged portions of the subsurface viewer consisted of four 150 cm long sections of clear acrylic tubing 4.42 cm ID and 0.32 cm in thickness (Figure 6). The end section of acrylic tube was fixed with a point attached at one end to facilitate sediment penetration. Ends of all sections were fitted with standard PVC male/female pipe thread connectors for 5.00 cm diameter pipe. This allowed various length combinations up to 7.2 meters in total length.

The viewer housing, that contained most of the optical apparatus, was attached above water to the top of the acrylic tubing. The housing was modified from a 90° telescope optical assembly purchased from Edmond Scientific catalog. The viewer housing contained an Amici prism erector that corrected for inversion and reversal of images. A Keller type eyepiece with fixed achromat objective lenses that provided a 9x optical magnification and a field of view reduction to 6° that focused the line of site directly down the acrylic tubing. Also attached to this assemblage was a 10 meter tape measure with increments, the end of this tape was fed through an opening in the back side of the viewer and could be lowered down the inside of the acrylic tubing.

Inside the acrylic tube a messenger was attached to a measuring tape. The messenger was constructed from 4.35 cm diameter acrylic rod with an overall length of 12.5 cm. At the top of the messenger a 45° beam director head (Edmond Scientific catalog #A36488) was attached and fitted with a 2.7 x 3.8 x 0.63 cm elliptic protected

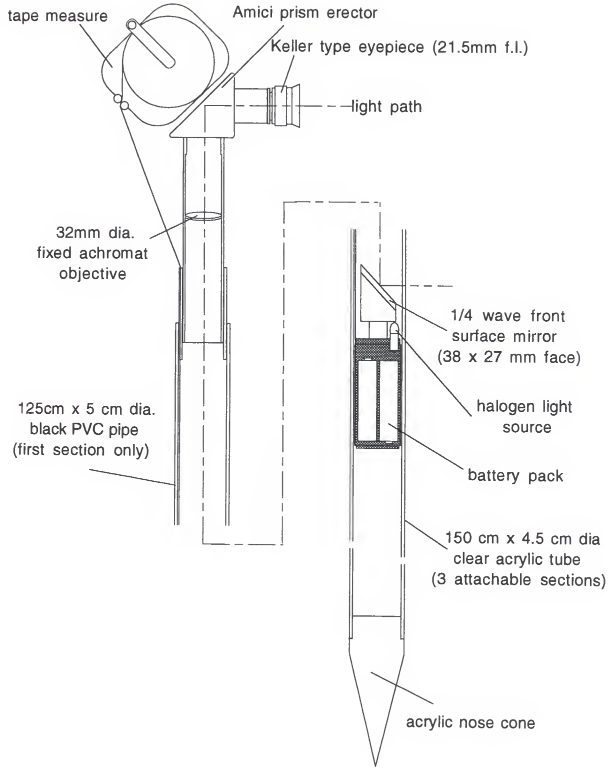


Figure 6. Cross section of subsurface viewer, scale 1:3 except where noted. Tape measure attached to messenger and zeroed at center of mirror.

aluminum mirror (Edmond Scientific catalog #A30837). Just below the elliptic mirror a socket for a halogen flashlight bulb was machined into the acrylic rod. Two AA batteries to power the light bulb were placed into two holes drilled in the lower part of the messenger. Connection between the flashlight bulb and batteries was by wiring in series. A wire nut was used to complete the circuit, turning the light on and off.

Subsurface Viewer Procedures

Viewer profiling began by gently inserting the acrylic tubing with pointed tip through the mat and assembling additional sections of tubing until point of refusal was met, and the open end of the tube was exposed above the water/mat surface. Next an opaque black cloth shroud was pulled over any section of the clear acrylic tubing exposed above the water surface. This was done to reduce refractory light that illuminates the inside of the acrylic tube and makes viewing the messenger mirror difficult. Next the messenger light bulb was turned on and the viewer housing threaded to the top of the acrylic tubing, first inserting the messenger attached to the tape measure inside the tube. Looking through the ocular of the viewer housing and continually adjusting focus to sharpen the image reflected by the messenger, the messenger was lowered to the air/water interface. This depth was noted and used as the reference for all other features noted. The messenger was then slowly lowered down the acrylic tube and features of interest were described and depth on tape measure noted. On bright days, it was also often helpful to shroud the observer's head and the housing assemblage with a dark opaque cloth. This made it easier to acclimate the observer’s eyes to the lower light conditions reflected at the messenger surface.

Discussion

Use of these sampling devices on Orange Lake provided high quality cores from sites that could not otherwise be sampled. Two hundred and nine sediment cores were collected on Orange Lake ranging in depth from 0.37 m to 4.10 m. Cores collected had minimal compaction or redistribution of roots and sediments within the core. Floating substrates were successfully retrieved ranging in thickness from 21.0 cm to 109.0 cm. Half and one third diameter segments of 12-cm diameter *Nuphar luteum* rhizomes were often collected from partially consolidated sapric lake bottom sediments. Cores collected in shrub swamp communities dominated by *Salix caroliniana* contained woody roots up to 3 cm in diameter with little apparent disturbance of peat or relocation of roots within the core. In all cores collected there was little or no evidence of rotational disturbance within the core sampled. This would indicate that the stationary teeth and stationary liner allowed the sediment to move into the liner with no apparent negative effect of outer housing rotation.

Although sampling in more flocculent open water sediments may have been equally facilitated by more specialized coring devices, and access to some sites required considerable effort to position and setup the coring platform, this coring device returned high quality sediment cores for peat stratigraphy and physical analysis of buoyancy. The cutting head and stationary core liner during operation, as well as more conventional large diameter core and piston components all attributed to the effectiveness of this coring device.

The viewing device was used at 34 floating and 8 open water sites. Although field of view was limited to a maximum of 15 cm radius around the acrylic tube, prominent features below floating communities were easily identified without disturbance of the mat. This allowed for description of the profile in-situ and identification of features otherwise lost with more destructive sampling techniques. Determination of mat bottom and bottom sediment surface also assisted in bracketing the sediment profile in preparation for coring of the site. Effective depth of the device was limited by acrylic tube alignment and decreasing size of messenger mirror with distance from ocular. Maximum depth application of the viewer as a result of these limitations is probably 3.0-3.5 meters. If greater depths are desired, ocular field of view, magnification and more precise alignment of acrylic tube sections could be implemented to increase usable depths of this device.

CHAPTER 4
PROFILE CHARACTERISTICS AND MAT COMPOSITION OF FLOTANT IN ORANGE LAKE, NORTH CENTRAL FLORIDA

Introduction

Flotant has been described in many wetlands and aquatic ecosystems throughout the world. This community is broadly defined as a floating mat of wetland macrophytes or a complex of macrophytes rooted in floating sediment. A few of these communities are floating *Papyrus* swamps along lakes and river systems in Africa (Ellery et al., 1990; Denny, 1984; Oliver and McKaye, 1982; Gaudet, 1977b, 1979), marshes dominated by *Paspalum* spp. in the Pantanal and Amazon basin (Junk, 1970), *Panicum hemitomon* marshes in the Mississippi River deltaic plain (Swarzenski et al., 1991; DeLaune et al., 1986; Sasser and Gosselink, 1984; Russel, 1942), and *Typha* spp. marshes in New Brunswick, Canada (Hogg and Wein, 1987, 1988) and Florida, USA (Stenberg and Clark, 1998) identify a few. Review of the literature indicates a global distribution of floating communities over a broad range of latitude, system size, and trophic state. These studies have provided descriptive details of above-water flora, fauna and physical conditions that occur on many of these systems. However, only a limited number of these investigations detail subsurface features such as biomass composition, species composition, substrate characteristics, or contrast subsurface characteristics of floating communities with non-floating wetland communities found within the same aquatic system. Because mat buoyancy and structural integrity are dependent upon these subsurface features, characterization of this component provides additional insight into formation mechanisms, buoyancy components and ecological habitat that these communities may provide.

Orange Lake located in north central Florida has a documented history of flotant formation dating back to the late 1700's (Bartram, 1792). Reversals in sediment radiocarbon dates suggest organic flotant communities occurred in Orange Lake as early as 1450 ± 70 AD (Warr et al., 1999). Recently, hydrologic management activities that have been implemented and are being proposed will reduce water level fluctuation in the lake and may affect formation of flotant. This proposed activity prompted questions related to flotant formation mechanisms, buoyancy components, influence of flotant on lake vegetation and the need for basic biophysical characterization of this atypical wetland type. This paper summarizes one of the surveys conducted in response to the need to characterize physical and vegetative composition of flotant that occurs on the lake.

Flotant, as compared to non-floating communities, is defined by a net positive buoyancy of vegetation and or substrate within the water column. The surface of this matrix typically floats at or above the water surface and can be exposed continuously or intermittently throughout the year (Glasser, 1986; Ellery et al., 1990). Above-water, vegetative composition of flotant ranges from herbaceous species dominated by floating aquatics such as *Eichhornia crassipies,* or *Pistea stratiotes* (Gopal, 1987; Goeltenboth, 1982), to woody shrub and tree species (Glasser, 1986; Southern et al., 1986; Cypert, 1972). Of those investigations that have studied below-water components of flotant, there are two general categories in which these communities can be classified; vegetative flotant, and organic flotant (Thompson, 1985).

In the case of vegetative flotant, the structure and floatation of the mat is provided by prostrate stemmed floating aquatic species, or species rooted in the bottom substrate that have positively buoyant stems that float near the water surface (Sculthorpe, 1967). Initially there is no organic substrate and colonization of open water occurs as a result of horizontal expansion from vegetation rooted along the shoreline (Kratz and Dewitt, 1986; Gopal, 1987; Thompson, 1985; Russell, 1942). On occasion physical disturbance of shoreline flotant can dislodge segments of the mat and islands of vegetative flotant can form. These islands can move freely in open water areas influenced by wind and currents (Oliver and McKaye, 1982; Junk, 1970).

In the case of organic flotant, buoyancy is principally provided by decomposition gases trapped within the organic sediment matrix (Hogg and Wein, 1988). Formation occurs when either non-vegetated organic sediments, or a combination of organic sediments and vegetation, delaminate from the bottom and begin to float at the water surface. Once floating, exposed sediments can provide suitable conditions for germination of seedbank species or establishment of new recruits. Organic flotant, similar to that of vegetative flotant, can occur as free floating islands or as communities attached along the shoreline (Mitchell, 1985).

Surveys of organic flotant in the Mississippi River Delta in Louisiana have characterized five classes of flotant substrates (Sasser et al., 1994; Swarzenski et al., 1991; Taylor, 1988). Flotant mats in these surveys ranged in thickness from 30-60 cm and were comprised of a root zone ranging from 0-15 cm thick and an organic base ranging from 20-40 cm thick. *Panicum hemitomon* alone or associated with *Sagittaria* *lancifolia* dominated three of the five classes. The other two classes were dominated by *Eleocharis baldwinii/Ludwigia leptocarpa* or the woody shrub *Myrica cerifera*. Bulk soil properties of the five classified flotant communities ranged from a density of 0.029 g cm^{-3} to 0.074 g cm^{-3} with organic content ranging from 64 % to 94 %. These surveys, in the Louisiana Delta, indicated a high diversity of below-ground profile features of flotant communities occurring, and emphasize the relationship between substrate characteristics, buoyancy, and above ground vegetative composition.

Similar to the Louisiana Delta, flotant on Orange Lake is diverse and complex with a variety of herbaceous and woody vegetative community types present. However, monodominant stands of *Panicum hemitomon* flotant do not occur on the lake, and organic flotant communities within the lake are species rich with a high heterogeneity among sites. In addition, extensive areas of vegetative marsh flotant and vegetative island flotant are also present on Orange Lake. These vegetative flotant communities were not described in the previously mentioned surveys of the Louisiana Delta, but are more similar to early development stages of flotant of the Louisiana Delta described by Russel (1942), or flotant communities of *E. crassipies E. azurea* or *Scirpus cubensis* flotant occurring in Africa and South America (Nogueira, 1996; Gopal, 1987; Goeltenboth, 1982; Little, 1969).

The apparent range in types of flotant communities occurring on Orange Lake, as well as the need to attain basic profile characteristics for management purposes offered an opportunity to compare and contrast these flotant communities with each other and with non-flotant bottom rooted emergent marsh communities. Specific objectives of this study were to 1) characterize profile features of flotant communities, 2) quantify below-ground vegetation of flotant communities based on biomass and volumetric displacement, and 3) relate findings to possible formation mechanisms and developmental processes occurring on flotant.

Materials and Methods

Study Site

Orange Lake is a shallow, warm temperate aquatic ecosystem located in north central Florida, USA. Lake size ranges from 3,500 to 5,000 hectares depending upon stage. Four low water events in the past 50 years have occurred lowering water levels 2.5 meters below normal stages. Hydrologic inputs to the lake are from two surface inflows draining catchments to the north and northeast (Figure 1). Outflows include a sinkhole located in the southwest section and an overland flow to the southeast. Surface flow to the southeast has been altered several times over the past 70 years, the most restrictive occurring in 1963 with a weir being constructed raising discharge elevation from approximately 15.8 m NGVD to 16.9 m NGVD. In 1990, this weir discharge was increased to 17.4 m NGVD.

The lake is also characterized by extensive emergent and flotant communities around the lake fringe. Wetlands are dominated by herbaceous species interdigitated by scrub-shrub swamp and tree islands. Lake trophic state since the early 1900's has been described as eutrophic according to diatom species assemblages in the water column and sediments (Brenner and Whitmore, 1996). Sediments are predominantly sapric to hemic organics averaging 1.35 m thick lake wide with some locations having depths exceeding 3.6 m (Danek et al., 1997).

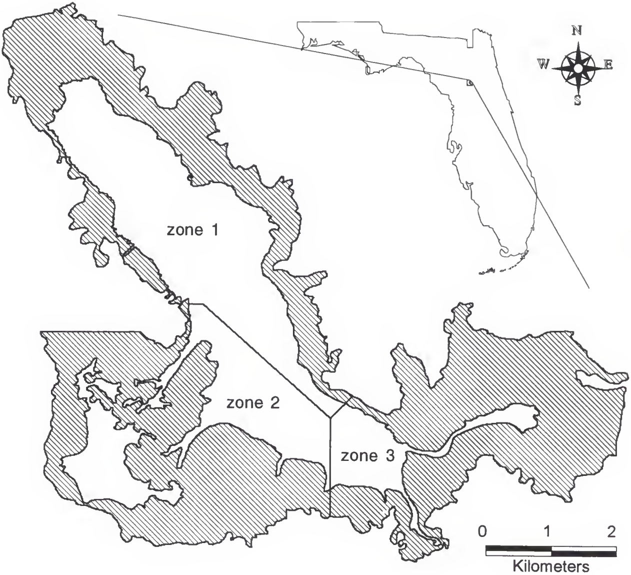


Figure 1. Map of Orange Lake depicting extent of fringing wetland communities (area with diagonal shading) and demarcation of lake zones used in stratified random selection of sampling sites.

Sample Site Selection

A previous vegetative survey of Orange Lake, conducted by the St. Johns River Water Management District and ground truthed in 1995, identified 18 community types in Orange Lake and the surrounding wetland ecosystem (Bryan and Warr, 1998). Using this survey five flotant communities (as delineated by Bryan and Warr, 1998), four bottom rooted emergent marshes (combination of 7 marsh types from Bryan and Warr, 1998), one scrub-shrub swamp (combination of two swamp types from Bryan and Warr, 1998) and one open water community (combination of two open water types Bryan and Warr, 1998) were selected for this study. For each community type, six sample sites were selected in a stratified random manner. Site selection was initially stratified into three lake zones to account for any possible spatial variations that may occur in flotant or emergent wetland characteristics (Figure 1). Random selection of vegetative community types was conducted using the pre-existing vegetation map (Bryan and Warr, 1998). This map was overlaid with a 500 X 500 m grid and grid intersects were randomly selected until two sample sites in each community were selected within each of the three lake zones. Grid intersection selection could not be used to determine sampling sites for island flotant communities due to their mobility. For island flotant, a random azimuth heading was taken from the centroid of each lake zone to locate sampling sites. Along each azimuth heading, an intercept width of 25 meters was followed until either the desired community or the edge of open water was intersected. When the desired island flotant community was found, a random fraction between 0.1 and 0.9 of the total transect distance across the island was calculated to demarcate the placement of the sample quadrat. The 0-0.1 and 0.9-1.0 fraction was rejected to avoid a pronounced edge effect, or placement of part of the sample quadrate in open water. If the desired community type was not intercepted, another heading, 180° away from the open water edge was selected and the process replicated until the desired island flotant community intercepted.

Profile and Composition Analysis

Prominent vertical profile characteristics were identified using a custom designed "viewer" device modeled after a technique developed by Bohm (1979) to profile roots in upland soils. The viewer consisted of a 4.5 cm dia, clear acrylic tube that ranged in length from 1.5 m to 4.5 m in length. Inside the acrylic tube a 45° mirror attached to a small messenger with light source could be lowered. Looking at the mirror through a 9X magnification lens mounted on the top of the tube, features 15 cm adjacent to the acrylic tube could be identified. A tape measure attached to the messenger was used to determine depth of prominent features relative to the water surface. After initially locating the site, the viewer acrylic tube was pushed through the mat surface in the center of a 2 m^2 quadrat being used for other studies. After 5 minutes, to allow any sediments that had been disturbed to settle, surface and bottom of the floating mat were measured and prominent features in the profile were identified and recorded.

When surveying the composition of flotant in Orange Lake, two methods were used due to substrate difference between vegetative flotant and organic flotant. For vegetative flotant, below-water species composition, biomass and displacement volume were surveyed by subsampling within a 2 m^2 quadrat used for above-water biomass collection. Within the 2 m^2 quadrat, four 0.25 m^2 quadrats were randomly selected. Each subsample was removed from the water column and placed in a water tight bag for transport to the laboratory. Quarter meter subsamples were then separated by dominant species present. Species having below-water biomass less than 5% of the total volume were lumped together and labeled as "other". Subsamples separated by species were then washed and allowed to air dry at 90% humidity until external surface water had evaporated. Volume of biomass was then determined by immersing biomass in a volumetric cylinder and measuring change in volume. Dry weight measurements were conducted by drying vegetation at 60° C for 48 hours or in the case of larger rhizomes until a constant weight had been attained.

Sediment and below-water biomass measurements of organic flotant and non-floating communities were conducted using a specially designed coring device that incorporates a cutting head and piston to minimize compaction and feature displacement. Three cores were randomly collected from within the 2 m^2 quadrat. Each core was 16.2 cm in diameter and taken to a length of 2 meters or the organic/mineral interface. Cores were maintained intact, transported to the laboratory and stored in a cooler prior to analysis within 24 hours. Cores were then extracted into a trough using a piston plunger. The core was then cut in half length wise exposing each half. Horizons of each core were identified based on texture, structure and color of organic sediment. Depth and thickness of each horizon were noted. Each horizon was then extracted from the core and live roots and rhizomes removed. Roots and rhizomes were then separated by species, washed and treated as above for volumetric displacement and dry weight measurements. Sediment density was conducted on the remaining sediment by drying at 60° C for 96 hours or until a constant weight was achieved. Calculation of bulk density required adding dry weight of root and rhizome biomass collected form each horizon to the sediment dry weight. This values was then divided by the total thickness of the horizon and multiplied by the cross sectional area of the core tube. Average bulk density values reported are 5 cm increment averages based on equal depth increments for each of the three cores taken at each site.

Results

Organic Island Flotant

Prominent features in the vertical profile of organic island flotant were organic sediments floating up to 6 cm above the water surface and averaging 0.7 cm above the surface (Figure 2). The surface of these floating islands often had an irregular microtopographic relief resulting from *Nuphar luteum* rhizomes lying just below the surface sediments, adventitious root masses developing micro hummocks, ant colony mounds, and irregular litter accumulation on the surface as a result of a diverse vegetative community. Organic island flotant typically had a surface sediment/root horizon averaging 11.3 cm thick infiltrated with roots and rootlets of vegetation growing at the site. This surface horizon was dominated by *Pontederia cordata*. Below the surface horizon, *Nuphar luteum* rhizomes dominated and accounted for over 85% of the biomass (Figure 3a) and volume (Figure 3b) of organic sediment profile. Rhizomes were found at the top, middle and bottom of floating organic sediments, but were typically within the top 30 cm of the profile. Average thickness of floating sediments infiltrated by roots and rhizomes was 28 cm, ranging from 0 to 57 cm. Thickness of floating organic sediment without any roots or rhizomes ranged from 0 cm to 103 cm and averaged 25 cm thick. The open water zone directly below the floating sediment was always low in suspended solids and appeared clear through the viewer with no live roots or debris dangling into the water below the floating mat. Thickness of the free water zone below this community

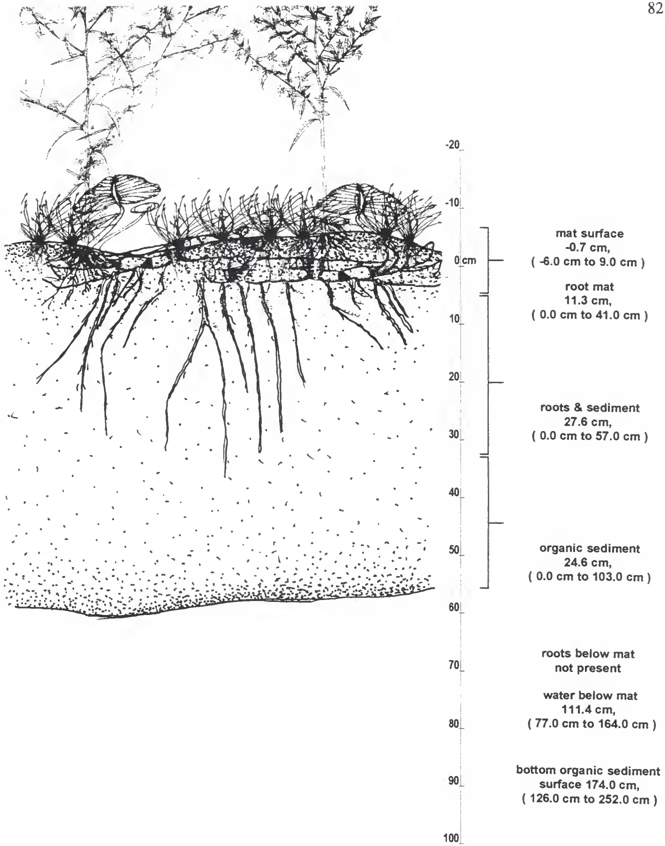
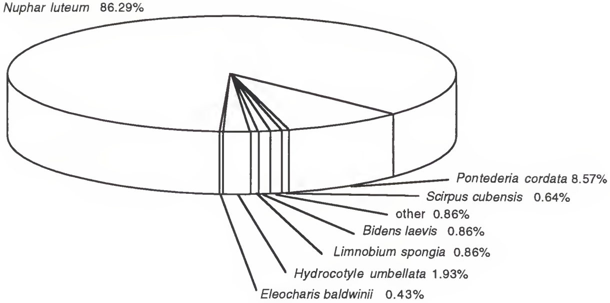
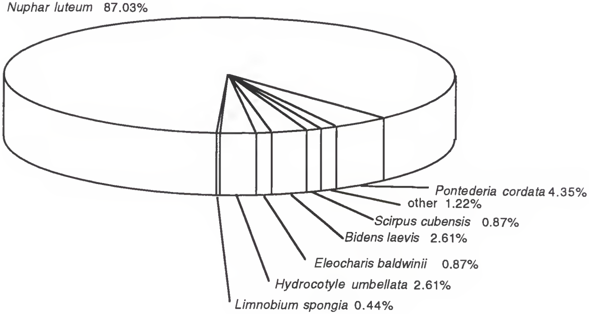


Figure 2. Characteristic profile of organic island flotant found on Orange Lake. Values below prominant feature label represent average thickness and range in thickness. "Zero" value on y axis represents water surface



(a)



(b)

Figure 3. Percent biomass (a) and displacement volume (b) of vegetative species found on organic island flotant. Average below water biomass of this community was 1,149 g m^{-2}. Average below-water displacement volume was 23,335 $cm^3 m^{-2}$.

averaged 111 cm and ranged from 77 to 164 cm. However, the mobility of island flotant communities makes the depth of the free water zone below the mat highly variable as a result of changes in depth with continuous relocation of the island.

Sediments of organic island flotant were principally composed of partially consolidated sapric sediments similar to that found in unvegetated open water areas. Sediment bulk densities of the mats were greatest at the surface of sites where sediments were exposed above the water surface (Figure 4). Most profiles showed higher density values in the top 5-10 cm than at the bottom of the floating mat, however, this was not a significant trend at all sites ($\alpha = 0.05$). An average bulk density among sites was 0.044 ± 0.020 g cm^{-3}. This was the lowest average value of all communities surveyed and significantly lower than non-floating *Panicum* marshes (Figure 5).

Organic Marsh Flotant

Sediment surface of organic marsh flotant averaged 8 cm below the water surface and ranged in depth below the surface from 3 to 17 cm (Figure 6). The surface topography of these floating sediments were often irregular and deviated up to 20 cm above the water surface and 20 cm below the water surface within the 2 m^2 quadrat of some of the sites sampled. Microtopographic relief in mat surface elevation appeared to be the result of adventitious roots of *Decodon verticillatus*, *Ludwigia leptocarpa* and *Bidens* spp., and true roots of *Thelypteris thelypteroides* that had developed when the mat was submerged. As changes in mat buoyancy occurred, adventitious roots previously below the water surface became exposed above the surface creating topographic highs. The upper horizon of the organic mat, defined by a mix of sediment and dense infiltration of live roots, averaged 22 cm thick, and was composed of up to 23 species. Dominant

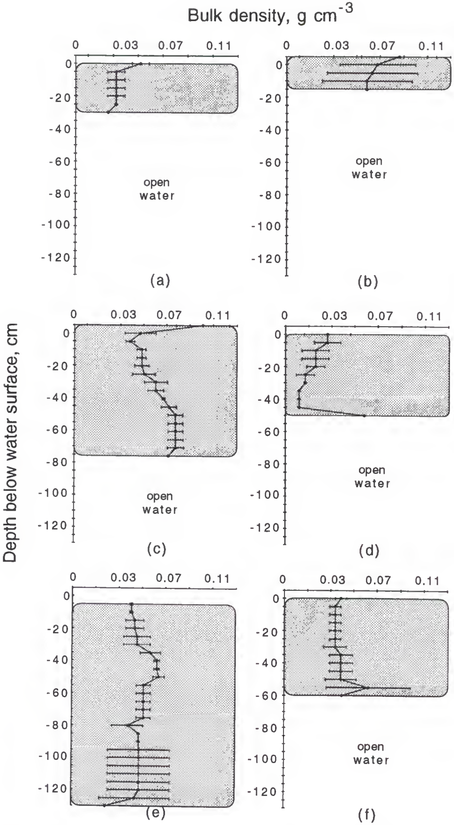


Figure 4. Sediment density profiles of sites sampled in organic island flotant. Values are average and standard deviation of three cores sampled at 5 cm incriments. Shaded area represents floating mat position in water column. Sample location and year are a) zone one, 1996; b) zone I, 1997; c) zone II, 1996; d) zone II, 1997; e) zone III, 1996; and f) zone III, 1997.

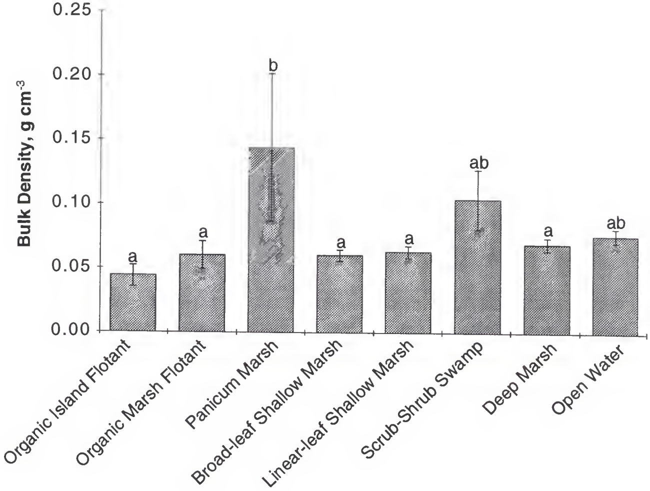


Figure 5. Average sediment profile density (mean ± 1SE). Lower case letters above columns represent significant differences between site average species richness values using Tukey's Honesty Significant Difference test of unequal sample size.

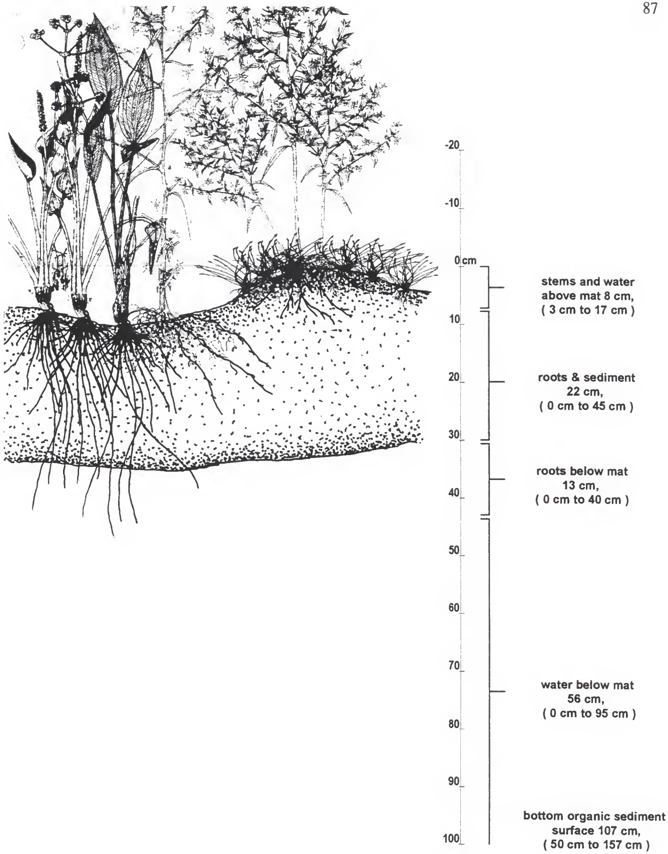

-20
-10
0 cm
10
20
30
40
50
60
70
80
90
100
stems and water above mat 8 cm, (3 cm to 17 cm)
roots & sediment 22 cm, (0 cm to 45 cm)
roots below mat 13 cm, (0 cm to 40 cm)
water below mat 56 cm, (0 cm to 95 cm)
bottom organic sediment surface 107 cm, (50 cm to 157 cm)

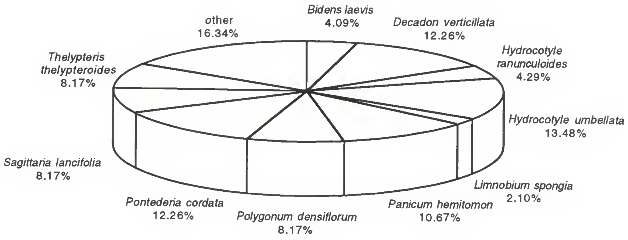
Figure 6. Characteristic profile of organic marsh flotant found on Orange Lake. Values below prominant feature label represent average thickness and range in thickness. "Zero" value on y axis represents water surface

species found at all sites and making up the largest percentage of the biomass were *Pontederia cordata* (12%), *Hydrocotyle umbellata* (13%) and *Decodon verticillatus* (12%) by mass (Figure 7a) and *Pontederia cordata* (20%) *Sagittaria lancifolia* (16%) and *Limnobium spongia* (13%) by volume (Figure 7b). Roots of these species often penetrated through the mat and were found extending into the water column below the mat to a depth of 40 cm. An open water zone below the extent of roots associated with the floating mat averaged 56 cm, and ranged from 0 to 95 cm. Depth to the bottom sediment surface in which this community was sampled ranged from 50 to 157 cm and averaged 107 cm.

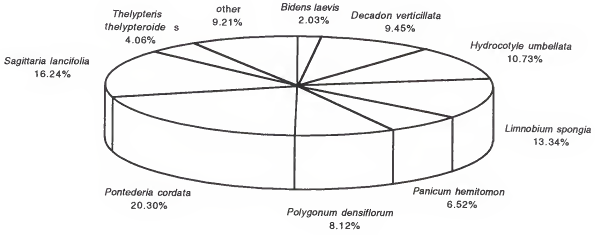
Unlike texture of organic sediments on organic island flotant communities, texture of organic marsh flotant was composed of fibric material of macrophyte origin. Bulk density of sediments typically increased with depth through the profile from 0.020 ± 0.007 g cm^{-3} at 0-5 cm below the water surface to 0.089 ± 0.037 g cm^{-3} at the bottom of each mat (Figure 8). Average density of sediments in the floating mat was 0.069 ± 0.014 g cm^{-3}. This was significantly less than the sediment density measured at non-floating *Panicum* marshes, but not significantly different from other communities surveyed.

Vegetative Island Flotant

By definition, vegetative island flotant had little or no associated organic sediments with the floating portion of the mat. Recent litter fall could be found intertwined in the root mat but fibric, humic or sapric sediments were typically absent. Structural composition of vegetative island flotant was therefore only comprised of vegetative tissue. On a biomass (Figure 9a) and volumetric basis (Figure 9b)



(a)



(b)

Figure 7. Percent biomass (a) and displacement volume (b) of vegetative species found on organic marsh flotant. Average below water biomass of this community was 652 g m^{-2}. Average below-water displacement volume was 6,427 $cm^3 m^{-2}$.

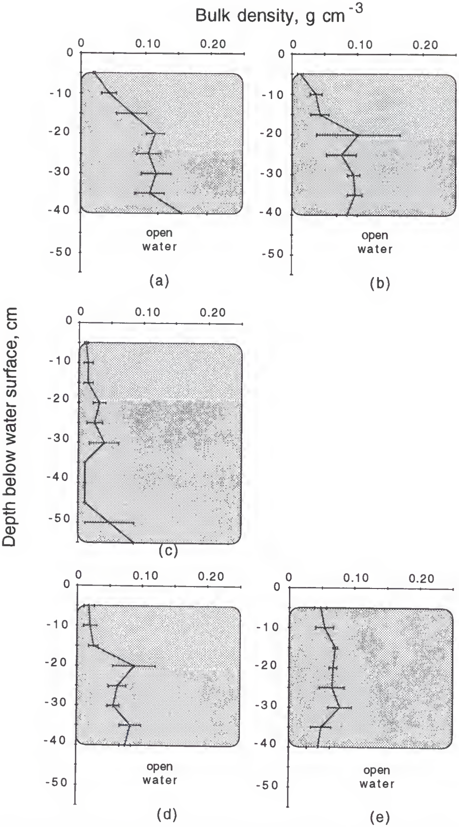
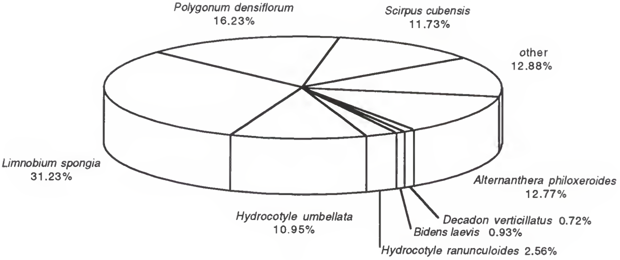
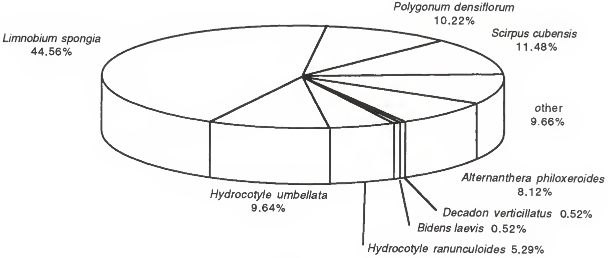


Figure 8. Sediment density profiles of sites sampled in organic marsh flotant. Values are average and one standard deviation of three cores sampled at 5 cm incriments. Sample location and year are a) zone one, 1996; b) zone I, 1997; c) zone II, 1996; d) zone III, 1996; and e) zone III, 1997.



(a)



(b)

Figure 9. Percent biomass (a) and displacement volume (b) of vegetative species found on vegetative island flotant. Average below water biomass of this community was 663 g m^{-2}. Average below-water displacement volume was 6,267 cm^{3} m^{-2}.

contribution to these mats was principally that of *Limnobium spongia*, *Polygonum densiflorum Hydrocotyle umbellata*, *Scirpus cubensis* and *Alternanthera philoxeroides*. Roots, rhizomes, stolons and prostrate stems of one or more of the these species were interwoven to provide structural integrity and buoyancy to the mat. The surface of the root mat was often quite distinct and averaged 18 cm below the water surface, and ranged from 3 cm to 75 cm in depth (Figure 10). The water column above the root mat was often densely covered with petioles and leaf litter . Thickness of the horizontal root mat horizon averaged 14 cm thick, and ranged from 5 to 46 cm thick. Below the root mat, roots, especially those of *Limnobium spongia* and *Scirpus cubensis* extended to depths ranging from 9 to 62 cm and averaging 31 cm. At two sites sampled the length of these roots below the mat were sufficient to reach the surface of the bottom sediment. Surface of the bottom organic sediments at the sampling sites ranged from 96 cm to 173 cm below the water surface and averaged 124 cm. Similar to organic island flotant, however, depth to bottom sediment is likely highly variable depending upon lake bathymetery and movement of the floating community.

Vegetative Marsh Flotant

Similar to vegetative island flotant, vegetative marsh flotant had little or no accumulation of organic sediments within the mat profile. These communities were always dominated by *Limnobium spongia*. This species accounted for 78 % of the floating mat biomass (Figure 11a) and 88% of the displacement volume within the mat (Figure 11b). The root mat surface of this community averaged 7 cm below the water surface and ranged from 3 to 10 cm in depth (Figure 12). Horizontal root mat thickness averaged 23 cm and was typically homogeneous in root distribution with exception of

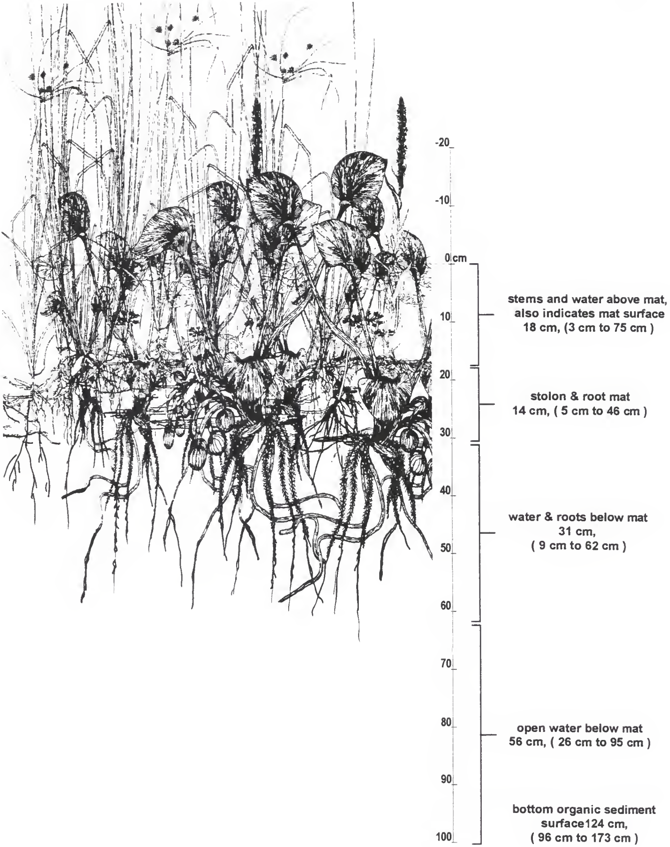
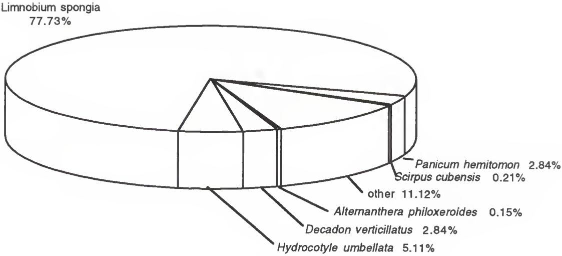
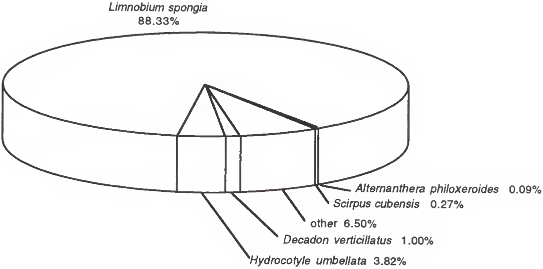

-20
-10
0 cm
10
20
30
40
50
60
70
80
90
100
stems and water above mat, also indicates mat surface 18 cm, (3 cm to 75 cm)
stolon & root mat 14 cm, (5 cm to 46 cm)
water & roots below mat 31 cm, (9 cm to 62 cm)
open water below mat 56 cm, (26 cm to 95 cm)
bottom organic sediment surface124 cm, (96 cm to 173 cm)

Figure 10. Characteristic profile of vegetative island flotant found on Orange Lake. Values below prominant feature label represent average thickness and range in thickness. "Zero" value on y axis represents water surface.



(a)



(b)

Figure 11. Percent biomass (a) and displacement volume (b) of vegetative species found on floating vegetative marshes. Average below water biomass of this community was 378 g m^{-2}. Average below-water displacement volume was 6,852 cm^3 m^{-2}.

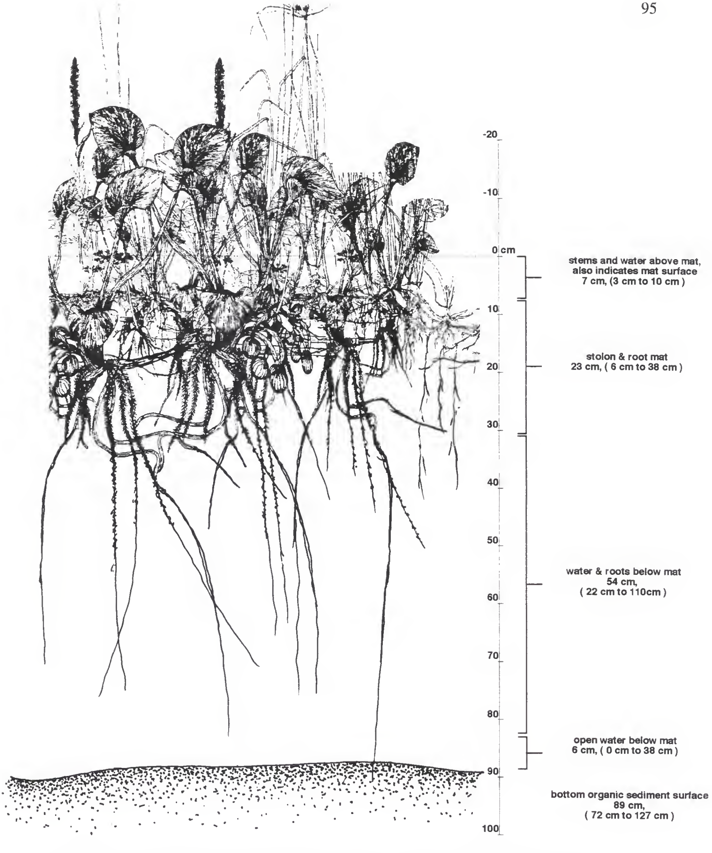


Figure 12. Characteristic profile of vegetative base floating marshes found on Orange Lake. Values below prominant feature label represent average thickness and range in thickness. "Zero" value on y axis represents water surface.

two of the six sites sampled. At these atypical sites the horizontal root mat was separated into three, and four distinct horizons, respectively. Each horizon consisted of dead *Polygonum densiflorum* stems laying in 5-10 cm thick horizontal bands separated by 5 to 15 cm thick zones of live *L. spongia* and *S. cubensis* roots connecting each of the layers. It appeared as if the live root layers were growing down through the multiple discrete levels of *P. densiflorum* than live roots extended below the horizontal mat zone and into open water. Each of the *P. densiflorum* layers appeared increasingly decomposed from the upper most horizon to the lower most horizon. Below the root mat of all sites, roots mainly of *L. spongia* extended to an average depth of 54 cm, and to a maximum depth of 110 cm. At several sites root ends penetrated into the bottom sediments up to 15 cm. At those sites not having roots that extended to the bottom sediment, an open water zone below the extent of floating mat roots averaged 6 cm thick and ranged from 0 to 38 cm in thickness. Depth to the surface of the bottom sediments averaged 89 cm.

Scirpus Vegetative Marsh Flotant

Scirpus vegetative marsh flotant was similar to that of vegetative marsh flotant with the exception that *Scirpus* marshes were dominated by *Scirpus cubensis*. This species made up 58% of the mat biomass (Figure 13a) and 46% of the displacement volume (Figure 13b). *Hydrocotyle umbellata* and *Limnobium spongia* were also significant components of this floating community. Profile of the *Scirpus* vegetative marsh flotant was similar to vegetative marsh flotant with the exception of overall root extension into the water column. The horizontal root mat surface averaged 6 cm below the water surface and averaged 18 cm in thickness(Figure 14). Root extension below the horizontal root mat averaged 31 cm and ranged from 17 to 39 cm. Open water zone below the extent of roots dangling below the floating mat averaged 65 cm and ranged from 0 to 104 cm. Surface of the bottom sediments below sites sampled averaged values of 111 cm, and ranging from 27 to 175 cm in depth.

Panicum Marsh

Panicum marsh communities on Orange Lake were previously thought to be floating similar to those of the Louisiana Delta region. However, my study did not find that to be the case. The vertical profile of this community indicated plants *of Panicum hemitomon* were firmly rooted in the bottom substrate with an adventitious root mat forming near the water surface. The adventitious root mat formed a partial floating substrate, although restricted in vertical movement by stem attachment to the bottom sediments. The adventitious root mat was composed principally of adventitious roots of *P. hemitomon,* but to a lesser extent also contained stems and roots of *Limnobium spongia, Hydrocotyle ranunculoides, Habinaria repens, Galium tinctorium,* and or *Polygonum densiflorum*. Entangled within the adventitious root matrix were dead stems and leaf litter of *P. hemitomon* likely intercepted during senescence of older stems. The surface of the adventitious root mat averaged 15 cm below the water surface and ranged from 12 to 17 cm below the water surface (Figure 15). Thickness of the adventitious root and stem mat averaged 18 cm, ranging from 15 to 21 cm thick. The adventitious root mat extended to the bottom substrate at one site, but at the other two sites an open water zone with *P. hemitomon* stems and some litter was present. This zone averaged 18 cm thick and ranged up to 44 cm thick. Depth to the bottom sediment of this community averaged 51 cm deep and ranged from 27 to 48 cm below the water surface.

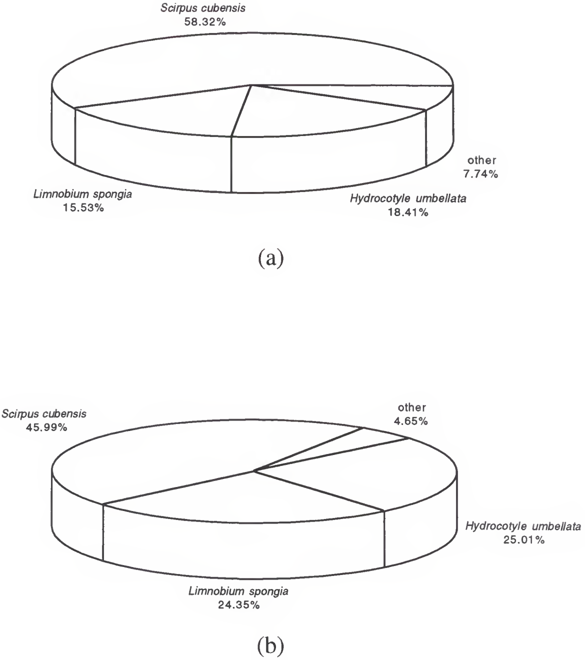


Figure 13. Percent biomass (a) and displacement volume (b) of vegetative species found on *Scirpus* vegetative marsh flotant. Average below water biomass of this community was 230 g m^{-2}. Average below-water displacement volume was 2347 cm^3 m^{-2}.

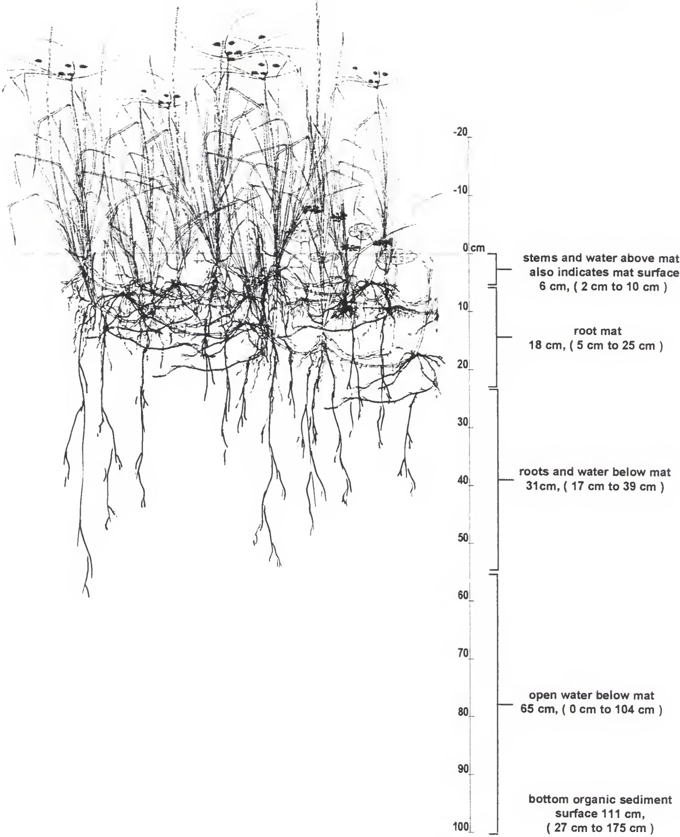
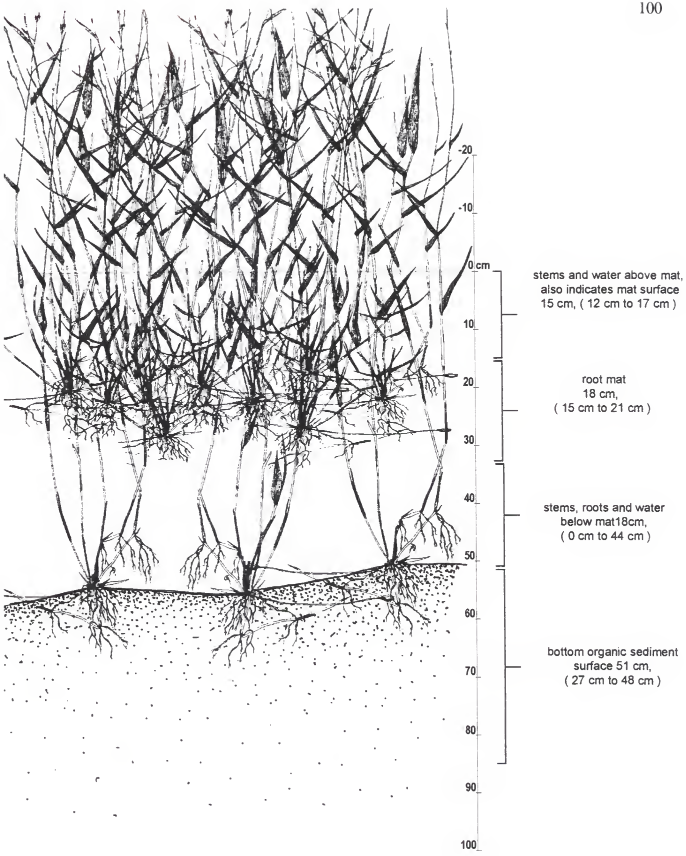


Figure 14. Characteristic profile of *Scirpus* vegetative marsh flotant found on Orange Lake. Values below prominant feature label represent average thickness and range in thickness. "Zero" value on y axis represents water surface.


-20
-10
0 cm
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50
60
70
80
90
100
stems and water above mat, also indicates mat surface 15 cm, (12 cm to 17 cm)
root mat 18 cm, (15 cm to 21 cm)
stems, roots and water below mat18cm, (0 cm to 44 cm)
bottom organic sediment surface 51 cm, (27 cm to 48 cm)

Figure 15. Characteristic profile of *Panicum hemitomon* marshes with associated floating species found on Orange Lake. Values below prominant feature label represent average thickness and range in thickness. "Zero" value on y axis r epresents water surface.

No organic sediments were found in the adventitious root mat and therefore sediment bulk densities were not determined for this portion of the profile. Bulk sediment densities of the bottom sediment averaged 0.144 ± 0.100 g cm^{-3} (Figure 16). This was the highest bulk density measured among all communities surveyed and was significantly greater than 5 of the 8 communities in which sediment bulk densities could be calculated (Figure 5).

Non-Floating Wetland Communities

As defined, non-floating communities did not have sediments or the dominant vegetative biomass floating in the water column. However, although considered non-floating emergent marsh communities, three communities had significant floating biomass as a component of the community. Deep Marsh communities dominated by *Nymphaea odorata*, broad-leaf shallow marshes dominated by *Peltandra virginica* or *Sagittaria lancifolia*, and linear leaf shallow marshes dominated by *Typha latifolia* or *Scirpus californica* all had significant contributions to above sediment biomass by species occurring on a floating mat (Figure 17). The floating portion of these communities was similar in species composition and structure to vegetative marsh flotant communities. A typical profile of these mixed communities is depicted in (Figure 18). Because water depths were typically shallower in emergent marsh vs. flotant communities, roots of species floating within an emergent marsh often extended to and penetrated the surface horizon of bottom sediments.

Average sediment bulk density of non-floating communities was intermediate in value between organic island flotant and *Panicum* marsh communities (Figure 5). Broad-leaf shallow marshes, linear-leaf shallow marshes and deep marshes had

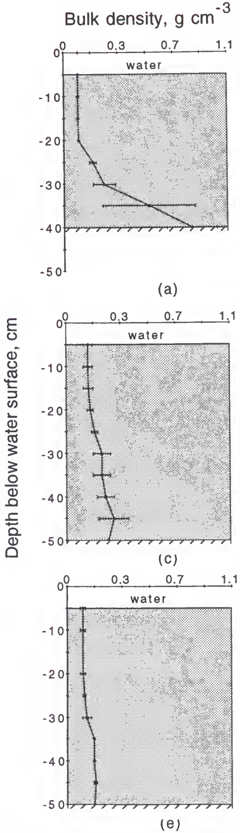


Figure 16. Sediment density profiles of sites sampled in *Panicum* marsh community. Values are average and one standard deviation of three cores sampled at 5 cm incriments. Sample location and year are a) zone one, 1996; b) zone II, 1997; and c) zone III, 1996.

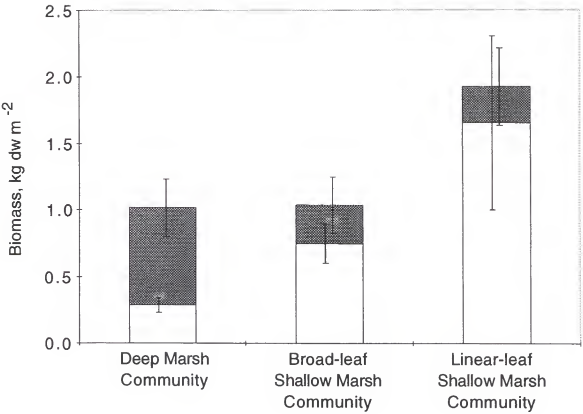
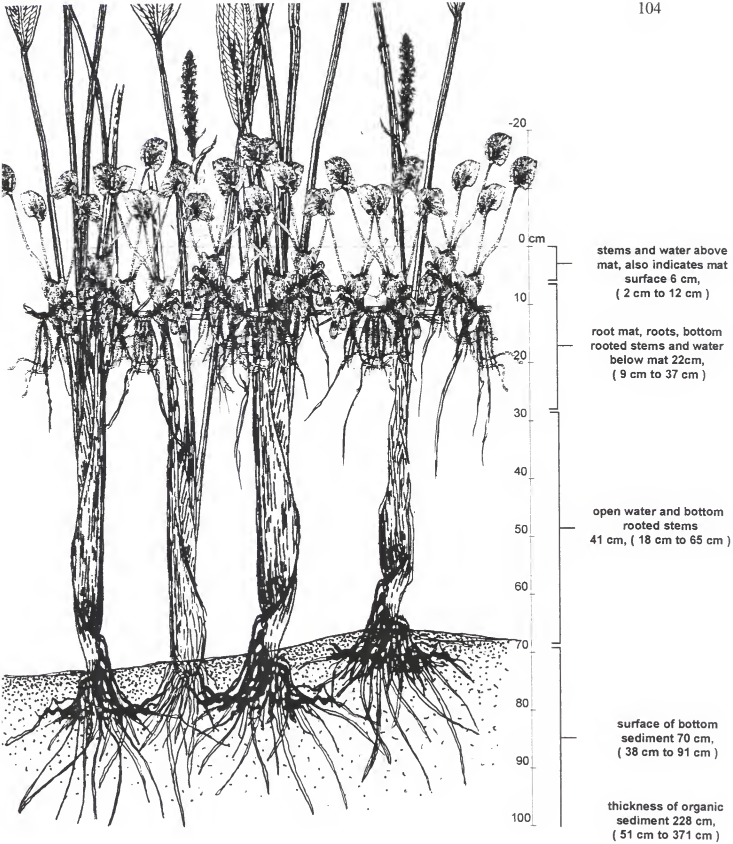


Figure 17. Above sediment biomass of communities having both emergent, and floating vegetation (mean ± 1 SD). Unfilled bars represent biomass of bottom rooted emergent vegetation. Filled bars represent biomass of floating vegetation within the water column.


-20
0 cm
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100
stems and water above mat, also indicates mat surface 6 cm, (2 cm to 12 cm)
root mat, roots, bottom rooted stems and water below mat 22cm, (9 cm to 37 cm)
open water and bottom rooted stems 41 cm, (18 cm to 65 cm)
surface of bottom sediment 70 cm, (38 cm to 91 cm)
thickness of organic sediment 228 cm, (51 cm to 371 cm)

Figure 18. Characteristic profile of broad-leaf shallow marshs with associated flotant found on Orange Lake. Values below prominant feature label represent average thickness and range in thickness. "Zero" value on y axis represents water surface.

significantly lower bulk density values than *Panicum* marshes. Bulk density profiles of non-floating communities were typically lower at the surface and higher at the organic mineral interface although this was not a significant trend at all sites. This trend was significant (α=0.05) at open water community sites, deep marsh sites and all other non-floating sites with organic sediments less than 75 cm thick.

Discussion

Profile characteristics of Orange Lake flotant identified in this survey provide several insights into flotant composition, development and possible formation mechanisms. Because selection of sampling sites was determined based on above-water vegetative characteristics, the range of below-water characteristics may not be completely sampled, however, one aspect that became clear from this survey is the considerable variation that exists below-water in these communities.

A clear difference below-water was noted between organic flotant and vegetative flotant, as well as differences between island flotant and marsh flotant. Within each of these groupings, however, range in mat thickness, biomass composition, and depth of mat above or below the water surface and extent of sediment/litter accumulation varied considerably. When contrasting organic island flotant with organic marsh flotant, sediment composition of island communities was principally sapric sediments of planktonic origin, whereas marsh flotant sediments were principally fibric macrophyte parent material. In addition, organic island flotant below-water biomass was principally composed of *N. luteum*, and organic marsh flotant was composed of numerous species with no one species accounting form more than 15% of the biomass or 25% of the displacement volume.

It is assumed that the composition of flotant is indicative of litter deposited by those communities presently occurring on the site and those communities that occurred on the site in the recent past. Therefore, because of the differences in profile characteristics between organic island flotant and organic marsh flotant it is postulated that these communities are likely of different origin. In the case of organic island flotant, planktonic based sediments and extensive *N. luteum* rhizomes within the sediment matrix could only develop prior to flotation. The large *N. luteum* rhizomes present are only remnant of the previous community from which the flotant formed with little or no above-ground *N. luteum* biomass present after flotation to support this tissue. The more likely conditions for sediment composition characteristics of organic flotant communities to occur in association with *N. luteum* is along the deeper water fringe wetlands surrounding open water of the lake and in large areas of McIntosh Bay in the southwest zone of the lake. In these areas, monodominant stands of *N. luteum* can occur in up to 2 m of water. After substrates emerge at the surface, *N. luteum* above-ground biomass is out competed by seedbank and low inundation tolerant species. Mechanisms that trigger the formation of island flotant from deep marsh communities is not clear, however, on several occasions newly formed "pop-ups" were noted to occur near areas of dense *N. luteum* vegetation and thick organic bottom sediments.

The significant dominance of *N. luteum* within the substrate matrix relative to the limited amount of above-ground leaves or petioles to sustain this below-ground biomass addresses another question of organic island flotant persistence. If *N. luteum* roots and rhizome are instrumental in buoyancy and or continuity of the organic matrix during initial formation, what happens to the integrity of the mat as *N. luteum* begins to senesce as a result of substrate flotation and subsequent competition with other vegetation colonizing the mat? It may be that loss of integrity and eventual loss of sediments may at some point compromise buoyancy causing the mat to sink. Or it may be that succession from *N. luteum* dominated biomass below-ground to a biomass composition more similar to that of organic marsh flotant will occur over time and these new rooted plants will replace the role of *N. luteum* in mat integrity. However, below-ground biomass dominance by any species other than *N. luteum* was not found on organic island flotant in this survey making this proposed successional transition only hypothetical.

In contrast to island flotant, organic marsh flotant was typically more common away from open water areas of the lake and rarely adjacent to *N. luteum* marshes. Because of the isolation from mechanisms hypothesized to form organic island flotant, it is likely that a different formation process may be occurring in the formation of organic marsh flotant. Sediments of this community were dominated by fibric material of macrophyte origin. It is possible that macrophyte sediments were deposited after flotant formed, thickening the mat substrate to the present conditions, or that organic substrates formed under emergent marsh conditions became buoyant and then were secondarily colonized by species presently colonizing these organic flotant marshes. Two lines of evidence would suggest the later formation mechanism to be more probable. First, density of organic substrate in organic marsh flotant was similar and not significantly different than that of emergent marsh communities. If sediments had formed after flotation, surface compaction would be minimal, because gravity would be pulling the mat apart instead of compacting sediments. Only litter accumulating at the surface of the mat, caught between the upward force of buoyancy and downward force of gravity, would be compacted similar to that of litter accumulating in an emergent marsh. Because sediment density of organic marsh flotant in Orange Lake was similar to that found on emergent marshes, findings tend to support the idea that the initial source of sediment material was that of a previous emergent marsh community that secondarily formed a floating mat. The second line of evidence refuting significant post flotation sediment accumulation is related to findings from the survey of vegetative marsh flotant discussed below.

Biomass composition of vegetative island flotant and vegetative marsh flotant indicate similar sources of formation , however, these communities appear to differ in secondary development processes. In both vegetative communities, *L. spongia, H. umbellata, P. densiflorum* or *S. cubensis* were dominant components of the below water biomass. However, in the case of vegetative island flotant, almost all of the biomass found associated with the island was live, with no sediment and little or no litter material within the mat. In contrast, litter material was common at vegetative marsh flotant sites and, at two sites, discrete bands of more recalcitrant litter from *P. densiflorum* were noted within the mat profile. These recalcitrant litter bands are hypothesized to represent annual die-back periods, which if true indicate that the mats were at least 3 and 4 years old, respectively. What this implies, with respect to vegetative communities, is that although carbon production is occurring at these sites from species known to have significant carbon production potentials, little or no sediment is accumulating. In free vegetative island flotant, movement and disruption of boundary layers and physical disturbance by wind and waves, may increase oxygen availability for decomposition or physically dislodge any accumulated organic material from within the mat area. In the case of vegetative marsh flotant, more litter was found, but organic sediments resulting from decomposition of vegetation within the mat were not present. This apparent inability to accumulate sediments within the mat matrix would tend to refute the hypotheses that vegetative flotant communities might eventually succeed to become organic marsh flotant or organic island flotant.

However, this conclusion may be limited by the number of sites surveyed in Orange Lake, regionally specific or significantly dependant upon the dominant species within the mat, how recalcitrant those species are, or what kind of decomposition environment is present on the mat. In the case of organic island flotant and vegetative marsh flotant, dominant species making up these mats, with one exception, were predominately that of herbaceous species with little woody tissue. These plants are likely to be relatively easily decomposed under all but the most reducing environments. The one exception is *P. densiflorum* that is more rigid and woody in composition and was also the only species to persist in the profile of two of the vegetative marsh flotant sites. If more recalcitrant species were present in a mat or if rates of decomposition decreased due to substrate quality, low temperature, reduced oxygen availability or some other means, it may be possible for sediment accumulation to occur on vegetative mats. This was likely the case in other studies that have reported mat sediment accumulation, specifically lower temperature in Canada, (Hogg and Wein, 1987) and more recalcitrant material from *P. hemitomon* as the dominant vegetation in the Louisiana Delta (Sasser et al., 1994). However, sediment accumulation on vegetative flotant was not identified in this study and therefore succession of vegetative island flotant or vegetative marsh flotant to organic flotant communities is not hypothesized to occur in the Orange Lake ecosystem.

The presence of vegetative marsh flotant was also not isolated to areas absent of bottom rooted emergent vegetation. Often vegetative marsh flotant was found in deep marshes not adjacent to open water, broad-leafed shallow marshes, or low stem density stands of linear-leaf marsh. This combined occurrence of flotant and emergent marsh species increased above-ground biomass of these sites considerably and contributed to the site vegetative species richness. However, long-term sustainability of this interaction between bottom rooted and flotant communities is questionable. It is likely that flotant would have some competitive advantages over emergent marsh communities if hydrologic conditions were excessively deep, sufficient to generate excessive stresses or reduce potential to recruit or re-establish emergent marsh vegetation due to life history requirements. Emergent marsh communities may have a competitive advantage of height under shallow water conditions and nutrient resources within the sediment. Nutrients potentially being limiting to floating species if water column nutrient availability were low. However, my survey found that many vegetative mats in these shallow water areas often had roots extending down to the sediment surface suggesting that possible nutrient limitation by a dependence upon the water column for nutrients may not be manifest. In addition, the occurrence of flotant in areas sparsely dominated by emergent species suggests that although emergent species may be able to intercept light resources first due to their height, reduced light in these areas was not sufficient to exclude floating species. Therefore, hydrologic conditions and the ability for emergent marsh species present to persist would appear the likely factor in determining the long term co-existence of flotant and emergent marsh communities. If water-level was stabilized , which is a proposed management strategy in this system, it may be that emergent communities would not be able to sustain their already limited presence and a conversion of these areas to exclusively vegetative marsh flotant could occur. These findings would indicate that two species in particular are influential in flotant formation in Orange Lake. These species are *N. luteum* in the case of organic island flotant, and *L. spongia* in the case of vegetative marsh flotant. It is also likely that *L. spongia* contributes to the development of vegetative island flotant, mainly because these are hypothesized to form as a result of fragmentation of fringing vegetative marsh flotant communities. Unlike the Louisiana Delta, *Panicum hemitomon* does not play a significant role in the formation of flotant communities on Orange Lake. Hypotheses formulated as a result of my survey will require long-term successional studies to test the hypotheses regarding formation mechanisms, developmental processes and interaction sustainability between flotant and bottom rooted communities as effected by water level management. Diversity of flotant communities in Orange Lake is considerable and the dissimilarity between many of the flotant communities characterized in this survey and that from the literature indicate a wide variability among this wetland type. And although basic buoyancy requirements would have to be similar between vegetative flotant or organic flotant, species specific relationships between buoyancy and mat integrity may vary considerably between systems as well as within the same system in which flotant forms.

Conclusions

This survey of below-water characteristics of flotant in Orange Lake has provided a better understanding of the composition of these communities, their physical setting within the water column and some insight into formation and successional development. A clear distinction between organic flotant and vegetative flotant was made. Organic island flotant had a large percentage of its composition composed of organic sediments and almost exclusive contributions of biomass from *Nuphar luteum* rhizomes. Organic marsh flotant did not have as thick an organic mat component and root and rhizome contributions were from multiple species that made up only a percentage of the overall composition. In vegetative flotant communities, little or no organic sediment was identified. Higher litter and remnant plant fragments of more recalcitrant species were found in vegetative marsh flotant than that of vegetative island flotant. At two locations live root material was layered between remnant stems of *Polygonum densiflorum* that may represent annual bands during periods of dieback. Lack of organic sediment in either vegetative flotant community, however, has led to the hypothesis that these communities do not succeed to organic flotant communities.

Dominant species associated with flotant in Orange Lake were *Nuphar luteum* on organic island flotant and *Limnobium spongia* on vegetative marsh flotant. The specific role these species play in initial formation or subsequent persistence is unclear and will require further investigation. Co-occurrence of vegetative marsh flotant and bottom rooted emergent species in many areas of Orange Lake may represent a transitional phase in succession. Management activities that promote vegetative marsh flotant communities may result in a loss of the emergent species in these communities and a complete dominance by flotant species in these transitional areas.

CHAPTER 5
BUOYANCY COMPONENTS OF FLOTANT AND EMERGENT WETLANDS IN A SHALLOW, WARM-TEMPERATE LAKE

Introduction

Flotant, defined as a floating mat of wetland macrophytes or a complex of macrophytes rooted in floating sediment, is a prominent features of many lakes. The phenomenon is not unique to Orange Lake and formation of flotant has been documented in many aquatic ecosystems around the world (Sasser, 1994). Flotant can occur as floating vegetation with little or no associated organic sediment (Nogueira et al., 1996; Gopal, 1987; Goeltenboth, 1982;) or as a complex of macrophytes and organic sediment (Trivedy et al., 1978; Glasser, 1986; Southern et al., 1986; Cypert, 1972; Sasser et al., 1995) . The most apparent difference in flotant, relative to other wetland communities, is the positive buoyancy of vegetation and sediments allowing it to move vertically with changes in internal buoyancy or fluctuations in water level. Factors hypothesized to provide buoyancy in flotant communities range from gases trapped within the sediment matrix (Powers, 1914; Krusi and Wein, 1988) to low-density macrophyte vegetation (Ellery et al., 1990; Reid, 1952; Russel, 1942; Krusi and Wein, 1988) to reduced percentage of mineral component within the sediment (Swarzenski et al., 1991). It is likely that each of these factors may be a component of buoyancy and depending upon type of flotant, contribute significantly to determine buoyancy. However, only one previous study has quantified buoyancy components of a floating marsh to determine what factors are most influential (Hogg and Wein, 1988).

The only study to quantify buoyancy was conducted in New Brunswick Canada, on flotant composed of a 60 cm thick organic peat mat and a monodominant mature stand of *Typha glauca* (Hogg and Wein, 1988). Five components of buoyancy quantified include: above-water fresh shoot mass and litter, live and dead organic solids, mineral soils, below-water gas content of living *Typha* and gas content of organic material below the water surface. Findings indicated a 25.7 kg m^{-2} positive (upward) buoyancy potential of the flotant, 92% of that was the result of gases trapped within the organic substrate. Gases within live *Typha* roots accounted for only 8% of the positive buoyancy. This study would indicate that sediment gases play a significant role in the buoyancy of organic flotant communities and may be the principal factor in their formation.

However, this is only one study of one type of flotant among many documented occurrences and types. These findings also raise the question that if gas accumulation in the sediment matrix is responsible for formation of flotant, why don't all aquatic communities with organic sediments eventually become buoyant. Since all wetlands do not appear to become flotant, what factors differentiate between the buoyancy budget of non-floating emergent marshes and those that become flotant?

Considering possible components of buoyancy that occur in wetlands, the potential for flotant formation is relatively high. Vegetation in wetlands is adapted to inundation conditions and as a result developed aerenchyma for internal gas transport. As aerenchyma forms, plant tissue becomes highly porous resulting in up to 60% porosity of the cross section area and therefore low tissue densities. Organic sediments also have low bulk densities (0.04 g dw cm^{-3} (Mitch and Gosselink, 1993) to 0.3 g dw cm^{-3} (Brady,

1999) being composed of particulate matter ranging from 0.9 g cm^{-3} (Brady, 1999) to 1.5 g cm^{-3} (Walmsley, 1977). In addition, although wetland sediments are considered saturated, gases produced and trapped within the sediment matrix have been reported to account for up to 11 %of the volume at 15° C (Hogg and Wein, 1988). When these components are combined, positive buoyancy potential is quite high. Counteracting these lifting components in non-floating wetlands, biomass, sediments, and interstitial water that occur above the water surface provide a sufficient negative effect on buoyancy to offset positive components. Below-water mineral particulates, when incorporated in the sediment complex, also contribute significantly to negative buoyancy (Swarzenski et al., 1991). These opposing components of buoyancy interact to determine whether a given location becomes positively buoyant and therefore floats or remains submerged.

Understanding the components that make up and provide the greatest contribution to positive and negative buoyancy may provide insight into the mechanisms of flotant formation. Objectives of this study were 1) to establish buoyancy budgets for flotant and non-floating communities in a shallow, warm-temperate lake, and 2) determine what differences, if any , exist between flotant and non-floating communities that regulate flotant formation.

Materials and Methods

Study Site

Orange Lake is a shallow (mean depth <2m), polymictic lake located in north central Florida (Figure 1). Lake size varies depending upon water level, and ranges from 1,600 to 5,600 ha at 15.2 and 18.3 m National Geodetic Vertical Datum (NGVD),

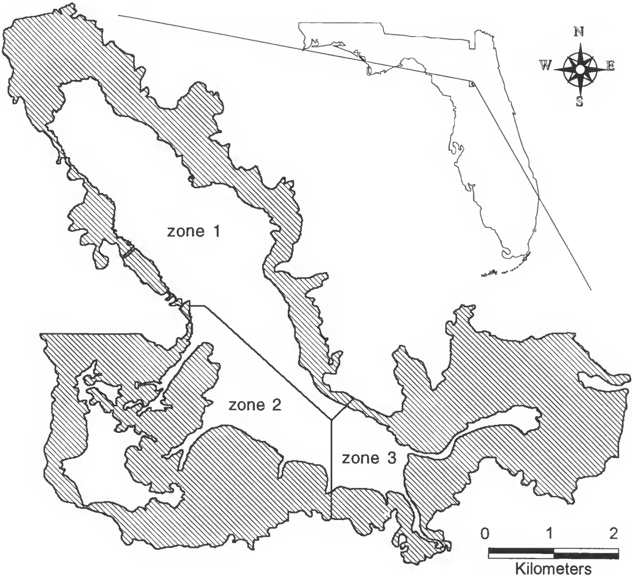


Figure 1. Map of Orange Lake depicting extent of fringing wetland communities (area with diagonal shading) and demarcation of lake zones used in stratified random selection of sampling sites.

respectively. Lake water level variations are common and result from short-term (5-10 yr) drought cycles. Lake level excursions on record of 3 meters occurred during the mid 1940's and 1960's with the minimum lake level recorded during the mid 1950's. In addition to these more extensive deviations, sub-decadal water level changes of one to two meters have been commonly measured since the late 1960's (Robison et al., 1997). Hydrologic inputs to the lake are principally from the north via the River Styx that drains a 356 km^2 water shed to the north. Lake effluent points are overland via Orange Creek in the southeast area of the lake and subsurface via a sinkhole at Heagy Bury park in the southwest area of the lake. Alterations to the overland outfall to Orange Creek have been modified over the past 100 years. Intervention by constructing a weir in 1963 raised discharge water levels to 55.5 NGVD. In 1990 the weir discharge elevation was increased to 57.1 NGVD, its present elevation. Sediments in the lake are predominantly sapric to hemic organics averaging 1.35 m thick lake wide with some locations having depths exceeding 3.65 m (Danek et al., 1997).

The history of flotant on Orange Lake is documented to the mid 1800's (McCall, 1868). Reversals in ^{14}C dates within the sediment profile, and peat stratigraphy of several sediment cores in Orange Lake, suggest relocation of organic sediments resulting from flotant has occurred as early as 1580 ± 70 AD (see chapter 6). This evidence suggests organic flotant has been a factor in the development of the lake ecosystem for at least four centuries.

Sample Site Selection

A previous vegetative survey by the St. Johns River Water Management District (Bryan, 1998) identified 18 vegetative community types occurring on Orange Lake.

These communities were broadly grouped into five flotant communities, two floating leafed marshes, five emergent marshes, two scrub-shrub swamps, two forested swamps, and two open water communities. Eleven community types were used in this survey and were either similar to communities identified by Bryan (1998), subsets of those communities or composites of Bryan's classified communities. All five of the flotant communities originally identified by Bryan (1998) were selected for this study. These included organic island flotant, organic marsh flotant, vegetative island flotant, vegetative marsh flotant, and *Scirpus* vegetative marsh flotant. Non-floating communities consisted of 1 deep marsh (2 combined from Bryan, 1998 survey), 1 scrub-shrub swamp (2 combined from Bryan, 1998 survey) and three emergent marsh communities, (two combined from Bryan, 1998) and *P. hemitomon* marshes. Community type characteristics and classification criteria for these communities can be found in Table 1.

Six sample sites were selected for each community in a stratified random manner. Site selection was stratified into three lake zones to reduce possible spatial effect (Figure 1). Location of each sample station was determined by overlaying a 500 x 500 m grid on a pre-existing vegetative community map (St. Johns River Water Management District Vegetative 1996). Each grid intersection was numbered. Grid intersects were randomly identified until two sample sites for each community type were selected within each of the three lake zones. The grid intersection selection method could not be used to determine sampling sites for island flotant communities due to their mobility. For organic island flotant and vegetative island flotant, a random azimuth heading was taken from the centroid of each lake zone to locate the sampling site. Once the azimuth

Table 1. Clasification criteria of wetland communities surveyed in this study. Criteria is based on substrate compositoin, connectivity to shoreline, and dominant vegetative species present.

Community type	Classification Criteria
Floating Communities	
Organic Island Flotant	Floating organic substrate surrounded by water or *Nuphar luteum,* vegetation varied low to tall macrophytes (*Eleocharis baldwinii, Amaranthus australis, Ludwigia leptocarpa. Eupatorium capillifolium*).
Vegetative Island Flotant	Floating vegetation with minimal accumulation of organic sediment, surrounded by water or *N. luteum*, vegetation dominated by *Limnobium spongia, Hydrocotyle* spp. *Polygonum densiflorum* and/or *Scirpus cubensis.*
Vegetative Marsh Flotant	Floating vegetation with minimal accumulation of organic sediment, floating mat attached to shoreline, vegetation dominated by *L. spongia* and/or *Hydrocotyle* spp.
Bulrush Marsh Flotant	Floating vegetation with minimal accumulation of organic sediment, floating mat attached along shoreline, vegetation dominated by *S. cubensis.*
Organic Marsh Flotant	Floating organic substrate, substrate attached along shoreline, vegetation rarely dominatted by a single species, *E. baldwinii, Decodon verticillatus*, *Bidens* spp. and *Ludwigia* spp. often present.
Non-Floating Communities	
Deep Marsh	Deep water bottom rooted wetland dominated by *N. luteum* and/or *Nymphaea odorata*
Panicum Marsh	Bottom rooted wetland dominated by *Panicum hemitomon.*
Broad-leaf Marsh	Bottom rooted wetland dominated by *Pontederia cordata, Sagittaria lancifolia* and/or *Peltandra virginica.*
Linear-leaf Marsh	Bottom rooted wetland dominated by *Cladium jamaicense, Typha latifolia* and/or *Scirpus californicus.*
Scrub-Shrub Swamp	Bottom rooted wetland dominated by *Salix caroliniana* and/or *Myrica cerifera.*
Open Water	Open water or areas only vegetated with submerged aquatic vegetation.

heading was determined from the lake centroid, a belt transect 25 meters wide was followed until either the desired community type, or the open water/marsh edge was encountered. If the desired island flotant community was found, a random fraction between 0.1 and 0.9 of the transect distance across the island was used to demarcate the placement of the sample quadrat. The 0.0-0.1 and 0.9-1.0 fraction was rejected to avoid a pronounced edge effect, or placement of part of the sample quadrate in open water. If the desired community type was not intercepted, another random heading was selected and the process replicated until the desired island flotant community was intercepted.

Components of Buoyancy

Eight buoyancy components were quantified in this survey, however, not all buoyancy components occur in all community types (Figure 2). Components of buoyancy were generally classified based on their positive (upward force) or negative (downward force) effect on buoyancy. All components above-water; live biomass, dead biomass and sediment and interstitial water, have a negative effect on buoyancy. Components below-water having densities less than water; shoot and stem biomass, root and rhizome biomass and gases trapped within the sediment matrix, all have positive effects on buoyancy. Below-water components having densities greater than water; organic sediment and mineral sediment, have a negative effect on buoyancy.

The term buoyancy, as used in this study, is defined as the force per unit area resulting on the plant/sediment complex. Direction of the resulting force is designated by a positive or negative value. Positive values apply an upward or lifting force, negative values apply a downward or sinking force. Units of buoyancy are kg m^{-2}. Quantification of buoyancy at a given sampling location required determination of buoyancy forces for

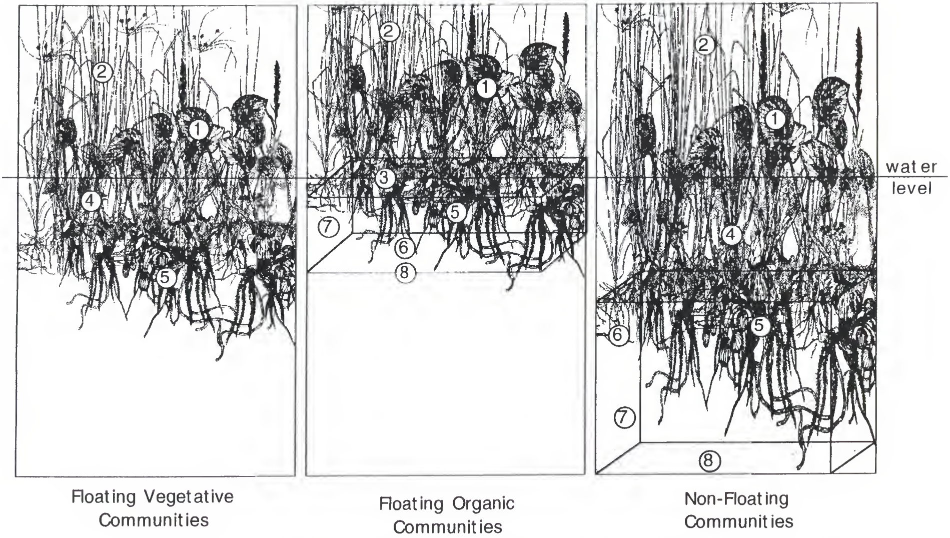


Figure 2. Components that make up buoyancy in three communities studied on Orange Lake. Buoyancy components represented by numbers are 1) above-water live biomass, 2) above-water dead biomass, 3) above-water sediment and interstitial water, 4) below-water shoots and stems above the substrate surface, 5) below-water roots and rhizomes, 6) below-water gases within the sediment matrix, 7) below-water organic sediments, and 8) below-water mineral sediments.

each of the eight buoyancy components. Overall site buoyancy for that community is determined by summing all of the individual components.

Collection and Calculation of Buoyancy

Buoyancy measurements were quantified within a 2 m^2 quadrat with 3:1 dimensions. After positioning the quadrat, an incision was made between the airboat and the quadrat, using a 2 m crosscut saw, making sure sediments and vegetation between the airboat and quadrat were no longer connected. This separation was imperative at flotant community sites to reduce the sinking effect the airboat and sampling activities had on sediments and vegetation within the quadrat. Once severed, sampling of buoyancy components within the quadrat occurred in three steps. First, above-water biomass within the quadrat was cut at the air water interface if the site was emergent, or at the sediment air interface if sediment occurred above the water surface. Only herbaceous species and small woody species <2.54 cm in diameter were collected at scrub-shrub communities. Larger diameter *Salix caroliniana* and *Myrica cerifera* individuals were present at these sites but were not collected. Cutting and removal was only conducted once, even though removal of above-water biomass often resulted in below-water biomass rising above-water due to changes in buoyancy. Biomass was placed in waterproof bags for transport back to the laboratory. During the collection procedure, attempts were made to prevent biomass from coming in contact with the water or sediment in order to minimize any weight change in the sample. Second, all of the below-water biomass from organic flotant communities or bottom-rooted communities was cut at the sediment water interface and placed in waterproof bags for transport to the laboratory. In the case of below-water biomass from vegetative flotant communities, below-water biomass was subsampled using four 0.25 m^2 quadrats randomly placed within the 2 m^2 quadrat. Subsample sections were cut from the rest of the mat using hedge clippers, drained and placed within waterproof bags for transport. Third, sediment and root biomass of organic flotant and non-floating sites were collected using three cores collected from random locations within the 2 m^2 quadrat. The coring device used was specifically designed for coring in floating and organic sediments. The corer consisted of a stationary inner head and rotating outer head resulting in a scissors like cutting action at the leading edge of the corer. The corer was also fitted with an inner piston reducing sediment compaction and preventing loss of gases during the coring operation. Core liners were 1 meter in length with 16 cm I.D. Cores were collected to a depth of 2 meters or to the organic mineral interface which ever was shallower. After collection core liners were capped at both ends and maintained upright for transport back to the laboratory.

In the laboratory, above-water and below-water biomass was sorted, weighed and volume determined. Biomass samples were sorted into at least 4 categories: 1) species with the greatest biomass, 2) species with the second greatest biomass, 3) a mixed category of lesser biomass species and 4) dead biomass of all species. Above-water biomass of each species was weighed fresh, then dried for a minimum of 48 hours at 60 °C, then reweighed dry. Below-water biomass was rinsed during sorting into similar groupings then air dried to remove water on the surface of the tissue. Care was taken not to desiccate the sample, but only to evaporate water on the external surfaces. Biomass was then weighed fresh and sample volume determined using water displacement within a 5,000 ml graduated cylinder. Samples were then dried for a minimum of 48 hours at 60°C and reweighed. Laboratory analysis of sediment and root biomass cores consisted of water content, organic and mineral content, below-ground biomass and gas content.

Each core with liner and end caps were weighed to the nearest 0.5 g using an O'haus model 1119 triple beam balance. The core was then extruded into a half round PVC trough 16 cm in diameter. Liner and cap weights were determined and subtracted from the total. Next the core was cut in half longitudinally, with a fine toothed serrated knife. One half of the core was placed in another PVC trough adjacent to the original core with the cut face upright. Unconsolidated cores that did not maintain their shape were contained using baffles. After exposing the core face, a visual and textural survey of the core was conducted, noting zones of different color and texture. Zones sufficiently different in either of these parameters were designated as different horizons. Thickness of each horizon was measured for later determination of horizon volume. Sediments and biomass of each horizon were then sorted, separating all living roots and rhizomes greater than 2 mm in diameter. Root and rhizome biomass were minimally washed to remove all sediment particles. Particles dislodged were collected in a 10 μm mesh screen and returned to the rest of the horizon sediment. Root biomass was then air dried until surface moisture was removed and fresh weight taken. Volumetric displacement of root biomass was determined by measuring the difference in mass resulting from submersion of biomass in a water bath placed upon the scale. Assuming the density of water was 1.0 g/cm^3, sample volume is equal to the change in mass registered on the scale. Samples were dried at 60° C for a minimum of 48 hours and weighed. Sediment from each horizon was dried at 60° C for a minimum of 72 hours then weighed. Sediments from each horizon were then homogenized and 50 mg subsamples collected for determination of carbon content. Samples were ashed at 525 ° C for 8 hours using a muffle furnace.

Organic sediment particle density was required to complete calculation of gas content. Because of the tedious nature of the analytical technique and small variability in particle density observed in a test study, a subsample of sediment particle densities, representative of those sediments found in the communities surveyed, was used in sediment volumetric calculations. Ten samples each from sapric, hemic and fibric sediments were collected from marsh sites and 10 sapric sediments from open water sites were randomly selected from all sites sampled and analyzed. Particle density analysis was conducted using the submersion method (Capek, 1933). Kerosene was used as the liquid for emersion due to it's increased wet ability of organic particles, lower density, and because of it's lower vapor pressure relative to other organic liquids often used in this method. Values for the subsamples analyzed were 1.399 ± 0.092 g cm^{-3} for sapric marsh, 1.394 ± 0.033 g cm^{-3} for hemic marsh, 1.306 ± 0.057 g cm^{-3} for fibric marsh and 1.408 ± 0.105 g cm^{-3} for open water sapric. Based on these results, all samples identified as sapric or hemic, regardless of location, were given an organic particle density of 1.40 g cm^{-3} and samples classified as fibric were give an organic particle density of 1.31 g cm^{-3}. Mineral particle densities were assumed to be that of quartz (2.65 g cm^{-3}) since this is the most common parent material found within the Orange Lake basin.

Gas content of each core was back calculated by subtracting mineral sediment volume, organic sediment volume, root and rhizome volume and water volume from the total core volume. Total core volume was determined in the field just after the core liner was extracted from the coring device. This measurement was possible by locking the piston in place after coring was complete but prior to liner extraction from the corer. Once extracted the distance between the end of the piston and the end of the liner, multiplied by the liner cross section areas, determined the overall volume of the core collected.

Site Buoyancy Budget

To determine the net buoyancy of a site, a simple balance of buoyancy components was used as follows. (Detailed calculations used to determine each of these buoyancy parameters can be found in Appendix E).

$$NSB = BA + RR + G - LB - DB - SW - OS - MS$$

where:

NSB = Net Site Buoyancy

BA= Biomass below-water but above the substrate (kg m^{-2})

RR = Root and Rhizome biomass (kg m^{-2})

G = Gases (kg m^{-2})

LB = Live above-water biomass (kg m^{-2})

DB = Dead above-water biomass (kg m^{-2})

SW= Sediment and water above the water surface (kg m^{-2})

OS = Organic sediments below-water (kg m^{-2})

MS = Mineral sediments below-water (kg m^{-2})

Statistical Analysis

Welsh ANOVA comparisons were used to analyze variance among community types for each buoyancy component (Sokal and Rohlf, 1969). When Welsh analysis indicated a significant ANOVA difference among community means, a Tukey-Kramer Honest Significant Differences Test comparison was used to determine differences among multiple means at the 0.05 % confidence level.

Results

Positive Components of Buoyancy

Three of the eight buoyancy components provide a lifting or positive buoyancy effect at each site. These include below-water stem and shoot biomass, below-water root and rhizome biomass and below-water gases trapped within the organic matrix. Below-water stem and shoot biomass buoyancy (averaged by community type), ranged from 0.00 ± 0.00 kg m^{-2} on organic island flotant communities and open water communities to 8.90 ± 10.0 kg m^{-2} in deep marsh communities (Table 2). These values were significantly different using Tukey Kramer Honest Significant Differences Test (TKHSD) of unequal means. Below-water stem and shoot biomass of flotant communities and open water community were all less than 1 kg m^{-2}, and were significantly less than deep marsh communities. Non-floating vegetated sites, other than deep marsh communities, had values ranging from 1.11 ± 1.84 kg m^{-2} (scrub-shrub swamp) to 4.85 ± 3.04 kg m^{-2} (broad-leaf marsh).

Root and Rhizome contributions to buoyancy ranged from 0.00 ± 0.00 kg m^{-2} in open water communities to 6.09 ± 5.55 kg m^{-2} in deep marsh communities. In flotant communities, root and rhizome contributions to buoyancy ranged from 0.76 ± 0.05 kg m^{-2} (*Scirpus* vegetative marsh flotant) to 3.59 ± 3.99 kg m^{-2} (organic island flotant). Non-floating vegetated communities root and rhizome contributions to buoyancy, excluding deep marsh communities, ranged from 0.23 ± 0.15 (scrub-shrub swamp) to 2.35 ±1.25 kg m^{-2} (broad-leaf marsh). Significant differences (TKHSD α=0.05) were found between organic island flotant, and between deep marsh communities and organic marsh flotant, shrub-scrub swamps and open water communities.

Table2. Community buoyancy components, mean ± 1 SD. Letter after buoyancy component value represent significance (α=0.05) among similar buoyancy parameters as determined by Tukey-Kramer comparison of unequal means. "NA" indicates buoyancy component is not aplicable to that community type.

Buoyancy Component	Floating Organic Islands kg/m^2 (n = 6)	Floating Organic Marshes kg/m^2 (n = 5)	Floating Vegetative Islands kg/m^2 (n = 6)	Floating Vegetative Marshes kg/m^2 (n = 6)
Above water				
Live Biomass (-)	2.92 ± 1.65 (c)	2.62 ± 1.01 (c)	1.27 ± 0.69 (abc)	2.14 ± 0.69 (bc)
Dead Biomass (-)	0.46 ± 0.50 (abc	0.78 ± 0.47 (bc)	0.17 ± 0.16 (ab)	0.45 ± 0.24 (abc)
water and sediment (-)	18.8 ± 19.71 (c)	0.55 ± 0.83 (ab)	0.00 ± 0.00 (a)	0.00 ± 0.00 (a)
Below-water				
organic sediment(-)	5.59 ± 5.04 (ab)	5.32 ± 1.41 (ab)	0.00 ± 0.00 (a)	0.00 ± 0.00 (a)
mineral sediment (-)	0.54 ± 0.71 (a)	0.02 ± 0.04 (a)	0.00 ± 0.00 (a)	0.00 ± 0.00 (a)
stem and shoot biomass (+)	0.00 ± 0.00 (a)	0.33 ± 0.66 (a)	0.63 ± 0.40 (a)	0.91 ± 0.51 (a)
root and rhizome biomass (+)	3.59 ± 3.99 (b)	1.04 ± 0.84 (a)	1.26 ± 0.81 (ab)	1.82 ± 1.02 (ab)
gases(+)	28.7 ± 22.57 (b)	12.36 ± 5.14 (ab)	0.00 ± 0.00 (a)	0.00 ± 0.00 (ab)

Buoyancy Component	Floating Bulrush Marshes kg/m^2 (n = 3)	Panicum Marshes kg/m^2 (n = 3)	Broad-leaf Shallow Marshes kg/m^2 (n = 6)	Linear-leaf Shallow Marshes kg/m^2 (n = 6)
Above water				
Live Biomass (-)	1.54 ± 0.68 (abc)	1.85 ± 0.73 (abc)	1.83 ± 1.08 (bc)	1.91 ± 0.85 (bc)
Dead Biomass (-)	0.42 ± 0.23 (abc)	0.50 ± 0.40 (abc)	0.65 ± 0.45 (abc)	0.98 ± 0.31 (c)
water and sediment (-)	0.00 ± 0.00 (abc)	0.00 ± 0.00 (abc)	0.00 ± 0.00 (ab)	0.00 ± 0.00 (ab)
Below-water				
organic sediment(-)	0.11 ± 0.16 (abcd	8.29 ± 4.86 (abc)	12.9 ± 5.89 (bcd)	13.3 ± 5.13 (bcd)
mineral sediment (-)	0.00 ± 0.00 (a)	3.40 ± 2.99 (a)	0.61 ± 0.81 (a)	0.66 ± 0.69 (a)
stem and shoot biomass (+)	0.49 ± 0.34 (ab)	1.28 ± 1.25 (ab)	4.85 ± 3.04 (ab)	3.16 ± 1.61 (ab)
root and rhizome biomass (+)	0.76 ± 0.05 (ab)	1.07 ± 0.62 (ab)	1.31 ± 1.01 (ab)	2.35 ± 1.24 (ab)
gases(+)	0.00 ± 0.00 (a)	13.9 ± 4.44 (ab)	30.3 ± 11.8 (b)	26.0 ± 9.88 (b)

Buoyancy Component	Shrub-Shrub Swamps kg/m^2 (n = 6)	Deep Marshes kg/m^2 (n = 8)	Open Water kg/m^2 (n = 9)
Above water			
Live Biomass (-)	0.60 ± 0.35 (ab)	0.53 ± 0.45 (ab)	0.00 ± 0.00 (a)
Dead Biomass (-)	0.13 ± 0.11 (ab)	0.01 ± 0.02 (a)	0.00 ± 0.00 (a)
water and sediment (-)	1.93 ± 4.32 (abc)	0.00 ± 0.00 (a)	0.00 ± 0.00 (ab)
Below-water			
organic sediment(-)	17.6 ± 7.34 (cd)	11.0 ± 3.21 (abc)	22.6 ± 8.75 (d)
mineral sediment (-)	1.15 ± 1.21 (a)	5.96 ± 5.79 (a)	4.60 ± 3.87 (a)
stem and shoot biomass (+)	1.11 ± 1.84 (a)	8.90 ± 10.0 (b)	0.00 ± 0.00 (a)
root and rhizome biomass (+)	0.23 ± 0.15 (a)	6.09 ± 5.55 (b)	0.00 ± 0.00 (a)
gases(+)	29.7 ± 10.8 (b)	24.3 ± 5.74 (b)	27.7 ± 8.48 (b)

Contribution of vegetation to below-water stem and shoot, as well as root and rhizome buoyancy, varied between communities and differed among species present. Among the 59 species identified at all communities, 15 were noted in sufficient abundance to be dominant in at least one community site surveyed. Contribution to buoyancy of a plant is related to the total biomass of that species as well as a factor of plant tissue density and water content. Buoyancy in units of gram dry weight of tissue varied considerably among the dominant species at sites surveyed (Figure 3). In addition, contribution to positive buoyancy by shoot/stem or by root/rhizome also varied by species. Species found associated with vegetative island flotant, vegetative marsh flotant or *Scirpus* vegetative marsh flotant typically had greater buoyancies per unit mass in root and rhizome tissue than that of stem or shoot tissue. Conversely, species associated with non-floating communities or rooted in sediment of organic island flotant or organic marsh flotant had greater buoyancy to mass ratios of stems and shoots than that of root and rhizomes. The combined effect of these tissue density effects on buoyancy and the total biomass at each given site result in the positive buoyancy contributions of below-water biomass noted above.

Where present, sediment gases contributed the greatest amount of positive buoyancy to the buoyancy budget. No gases were found in vegetative island flotant, vegetative marsh flotant or in *Scirpus* vegetative marsh flotant. In communities that gases were present buoyancy contributions ranged from 13.9 ± 4.44 kg m^{-2} in *Panicum* marshes to 30.3 ±11.8 kg m^{-2} in broad-leaf marshes . Only *Panicum* marshes and organic marsh flotant had buoyancy values less than 24 kg m^{-2}. All other community site averages ranged between 24 and 30 kg m^{-2}. No significant differences among communities having sediment gases were found (TKHSD α=0.05). Because sediment

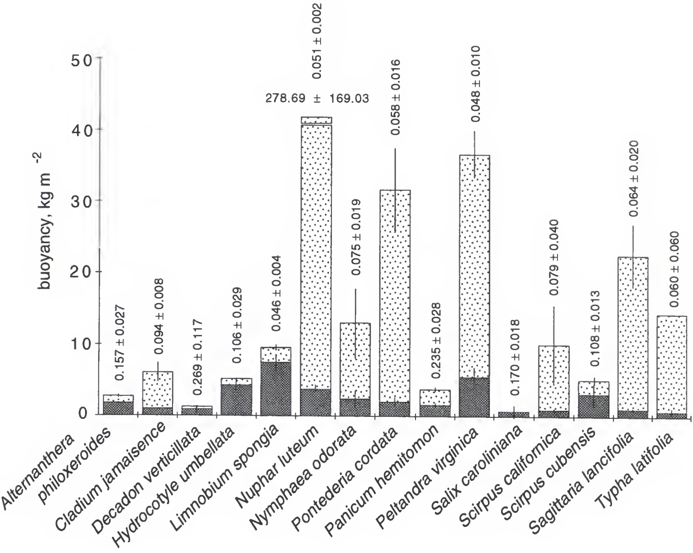


Figure 3. Species buoyancy of below-water tissue (mean gdw ± 1SE). Light shading represents buoyancy of stem or petiole biomass, darker shading represents buoyancy of root or rhizome biomass. Values vertically oriented above histogram represent average below-water tissue density of respective species (mean gdw cm3± 1 SE).

depths varied between sites. Expressing gas content on a volume of gas per volume of sediment basis provides a normalization of percent gas content in sediments between sites. Using this normalization, percent gas volume was lowest in open water communities (2.24 ± 0.73 %) and greatest in organic marsh flotant communities (5.18 ± 1.11 %) (Figure 4). These two sites differed significantly (TKHSD α=0.05). All other sites averaged gas volumes between 3.4 % and 4.1 %.

Combined contribution of all three buoyancy components indicated significant differences in positive buoyancy between communities (Figure 5). Net positive buoyancy for all communities ranged from 1.25 ± 0.37 kg m^{-2} on *Scirpus* vegetative marsh flotant to 39.3 ± 10.2 kg m^{-2} at deep marsh communities. With the exception of *Scirpus* vegetative marsh flotant, organic marsh flotant and *Panicum* marshes, vegetative island flotant and vegetative marsh flotant had significantly lower net positive buoyancy than all other communities surveyed.

Negative Components of Buoyancy

There were five components contributing negatively to buoyancy; above-water live biomass, above-water dead biomass, above-water sediment and interstitial water, below-water organic sediment and below-water mineral sediment. Organic island flotant had the greatest negative contribution to buoyancy by above-water live biomass averaging -2.92 ± 1.65 kg m^{-2} (Table 2). Negative buoyancy by above-water biomass in other communities ranged from 2.62 ± 1.01 kg m^{-2} in organic marsh flotant to 0.53 ± 0.00 kg m^{-2} in deep marshes. Negative buoyancy contributed by above-water live biomass was significantly greater on organic marsh flotant and organic island flotant than that in scrub-shrub swamps or deep marshes (TKHSD α=0.05). It is likely, however, that

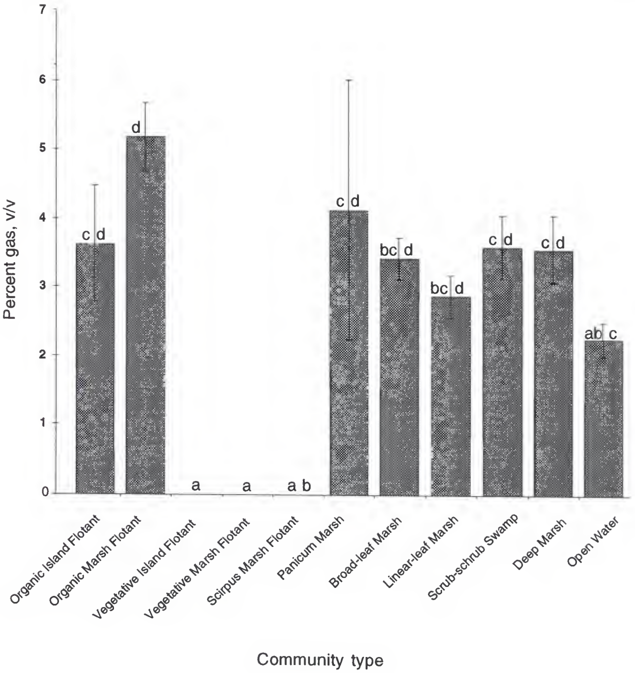


Figure 4. Average percent sediment gas volume , mean ± 1 SE. Values represent volume/volume percent of gas within floating mat of floating communities or above the mineral/organic substrate in emergent marsh, swamp and open water communities. Different letters designate significant differences between means using Tukey-Kramer Honesty Significant Differences test (α=0.05).

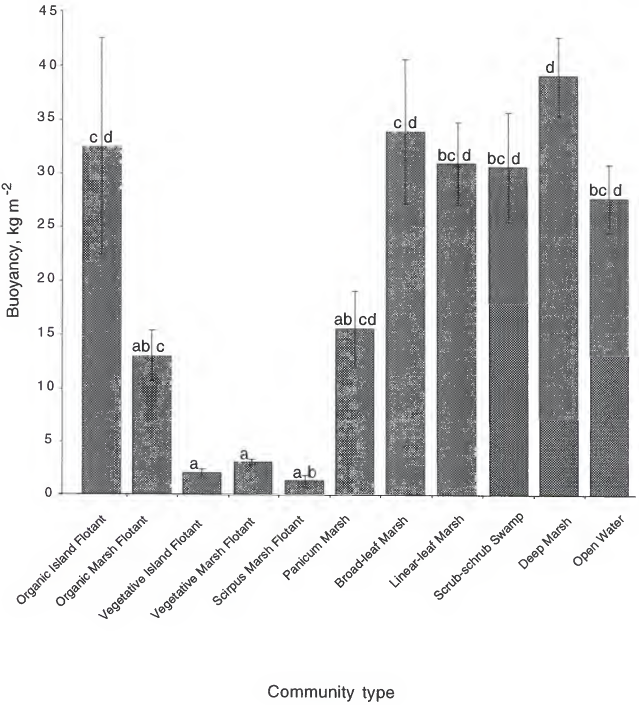


Figure 5. Positive buoyancy of communities surveyed , mean ± 1 SE. Values represent sum of positive components of buoyancy within floating mat of floating communities or above the mineral/organic substrate in emergent marsh, swamp and open water communities. Different letters designate significant differences between means using Tukey-Kramer Honesty Significant Differences test ($\alpha = 0.05$).

if woody biomass greater than 2.5 cm in diameter had been collected as scrub-shrub community sites, this community would not be significantly less than organic flotant communities and may actually have been significantly greater in above-water biomass than other communities.

Above-water dead biomass contributions to negative buoyancy were greatest in linear-leaf marshes (-0.98 ± 0.31 kg m^{-2}) and had the least effect in deep marsh and open water communities ($\geq$ -0.01 ± 0.02 kg m^{-2}). Values for other communities ranged between -0.13 ± 0.11 kg m^{-2} in scrub-shrub swamp communities to -0.78 ± 0.47 kg m^{-2} in organic marsh flotant communities. Significant differences related to above-water dead biomass were ground between linear-leaf marshes and vegetative island flotant, scrub-shrub swamps, deep marshes and open water communities. Organic marsh flotant also had significantly greater negative buoyancy related to above water dead biomass than deep marshes and open water communities.

Negative buoyancy effects related to interstitial water and sediment above the water surface were only found in three communities; floating organic islands, floating organic marshes and scrub-shrub swamps. Average values were lowest in floating organic marshes (-0.55 ± 0.83 kg m^{-2}) and greatest in organic island flotant (-18.8 ± 19.71). The contribution of above-water sediment and interstitial waters on organic island flotant was significantly greater than all other communities with the exception of scrub-shrub swamps (TKHSD $\alpha = 0.05$).

Negative buoyancy contributed by below-water organic sediments ranged from 0.00 ± 0.00 kg m^{-2} on vegetative island flotant and vegetative marsh flotant to 22.6 ± 8.75 kg m^{-2} at open water communities. Open water community organic sediment negative buoyancy was significantly (TKHSD α=0.05) more negative than organic sediments on organic island flotant, organic marsh flotant, vegetative island flotant or vegetative marsh flotant. Organic island flotant and organic marsh flotant had approximately the same average negative buoyancy contributed by below-water organic sediments, -5.59 ± 5.04 kg m^{-2} and -5.32 ±1.41 kg m^{-2}, respectively. Non-floating vegetated marshes and swamps had below-water organic sediment contributions to buoyancy ranging from -8.29 ± 4.86 kg m^{-2} (*Panicum* marshes) to -17.6 ± 7.34 kg m^{-2} (scrub-shrub swamps).

Mineral sediments were absent in floating vegetative islands, floating vegetative marshes and floating Bulrush marshes. In those communities where mineral sediments were identified, negative contributions to buoyancy ranged from 0.02 ± 0.04 kg m^{-2} to 5.96 ± 5.79 kg m^{-2}. No significant differences were found between communities. This is likely due to the high site specific and core specific variability found in the occurrence of mineral sediments during this survey.

When negative components of buoyancy were combined, net negative buoyancy for each community ranged from -1.44 ± 0.82 kg m^{-2} for vegetative island flotant to -28.3 ± 25.7 kg m^{-2} on organic island flotant (Figure 6). Non-floating communities averaged negative buoyancies greater than -14 kg m^{-2}. Significant differences in negative buoyancy were determined between all vegetative flotant communities and organic island flotant, organic marsh flotant and non floating communities. No significant differences in net negative buoyancy were identified between organic island flotant, organic marsh flotant or within non-floating communities.

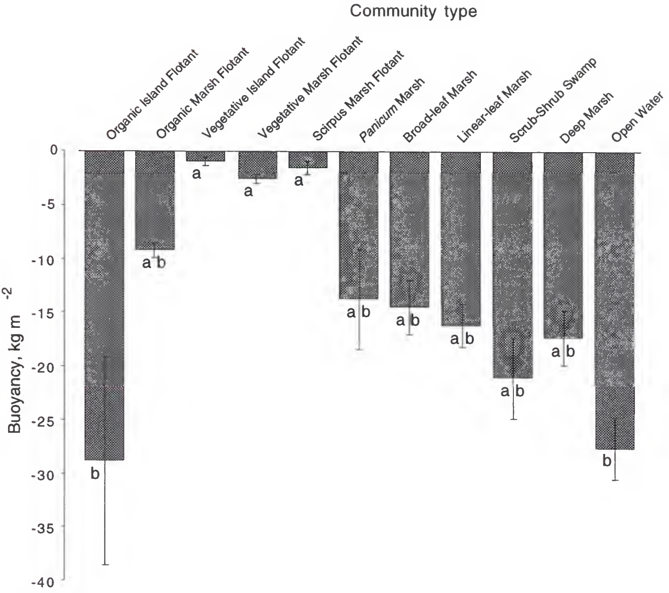


Figure 6. Negative buoyancy of communities surveyed , mean ± 1 SE. Values represent sum of negative components of buoyancy within floating mat of floating communities or above the mineral/organic substrate in emergent marsh, swamp and open water communities. Different letters designate significant differences between means using Tukey-Kramer Honesty Significant Differences test (α=0.05).

Community Net Buoyancy

Community net buoyancy, defined as the sum of buoyancies of each of the eight buoyancy components, varied among communities, but with the exception of *Scirpus* vegetative marsh flotant were all positive (Figure 7). Flotant community net buoyancy averaged less than 5 kg m^2. Of these floating communities, organic flotant communities had the greatest values, 3.96 ± 2.64 kg m^{-2} (organic island flotant) and 4.44 ± 2.37 kg m^{-2} (organic marsh flotant). Vegetative flotant community net buoyancies ranged from -0.71 ± 0.59 kg m^{-2} (*Scirpus* vegetative marsh flotant) to 0.46 ± 0.67 kg m^{-2} (vegetative island flotant). Non-floating vegetated communities had net buoyancy values greater than that of floating communities, and with the exception of Panicum marshes were significantly greater (α=0.05) than all three vegetative flotant communities and organic island flotant. The greatest net buoyancy value of any community was that of deep marsh communities averaging 22.1 ± 4.39 kg m^{-2}. The smallest net buoyancy determined for non vegetative floating communities was that of open water that had a value of 0.49 ± 2.66 kg m^{-2}, which was significantly less than values reported for all of the vegetated marsh communities and for organic marsh flotant.

Discussion

Findings suggest two general buoyancy budget signatures occur on flotant, one characteristics of vegetative flotant, and one characteristics of organic flotant. Buoyancy components of vegetative flotant indicate that below-water biomass of stems, shoots, roots and rhizomes are the only component that contributes to positive buoyancy. No gases were quantified within the below-water stem/root mat. As defined, vegetative

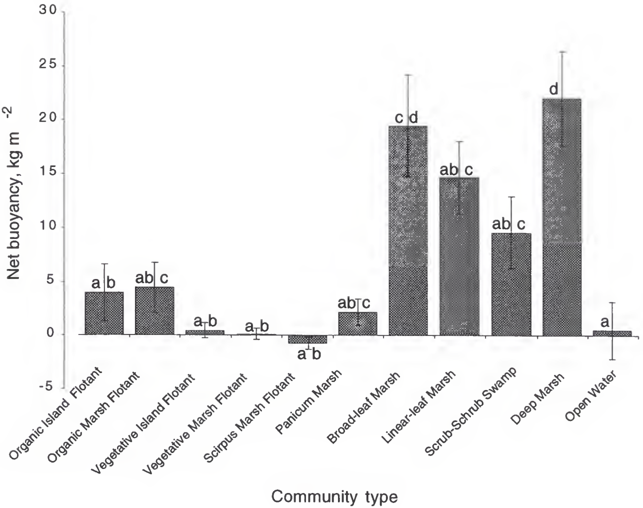


Figure 7. Community net buoyancy, mean ± 1 SE. Values represent sum of positive and negative components of buoyancy within floating mat of floating communities or above the mineral/organic substrate in emergent marsh, swamp and open water communities. Different letters designate significant differences between means using Tukey-Kramer Honesty Significant Differences test (α=0.05).

flotant had no organic or mineral substrates associated with the mat. It is hypothesized that the absence of sediment in this type of mat system eliminates a suitable matrix for gases to be produced and or trapped. Therefore, gases are not a source of positive buoyancy for vegetative flotant.

The absence of organic or mineral substrate in vegetative flotant also suggests that negative contributions to buoyancy can only result from above-water live and dead biomass. In the absence of sediment contributions to negative buoyancy and gases to positive buoyancy, net buoyancy of vegetative flotant is regulated by tissue density of those species making up the floating mat. One might expect tissue densities of these species to be low relative to non-floating wetland species. However, below-water density of shoot/stem and root/rhizome of vegetation found on vegetative flotant was not significantly different than that of other wetland species sampled. In fact, many species not typically associated with vegetative flotant had lower tissue densities than that of species typically dominant on vegetative flotant. Therefore, even though tissue density of species found on vegetative flotant was sufficient to provide positive buoyancy, a significantly greater tissue buoyancy was not found, thus excessive buoyancy by species associated with vegetative flotant is not likely the only factor allowing these communities to become established.

An additional feature of vegetative flotant, not measured in this survey, is the growth habit of species found on vegetative flotant that may be equally advantageous to the formation of this community. Dominant species found on vegetative flotant typically have prostrate stems, fibrous branching root systems, and a low vertical to horizontal ratio of biomass distribution. This is in contrast to species found in emergent marshes where the ratio of vertical growth relative to horizontal growth would appear to be greater. In addition, an interconnected network of stolons and roots often forms as a result of this growth habit that provides connectivity between plants. This may be important to the persistence of the mat especially under increased physical disturbance in open water areas of the lake.

Organic flotant, unlike vegetative flotant communities, often had considerable sediment and gas contributions to buoyancy. The principal component to positive buoyancy was that of gases trapped within the sediment matrix, which comprised between 2.24 and 5.18 % of the sediment matrix by volume. Gas concentrations, although significant contributions to positive buoyancy, were less than half that reported by Hogg and Wein (1988) at 15° C under laboratory incubation of *Typha* dominated flotant from Canada (11%). In all but one community (including organic flotant and non-floating communities), buoyancy of sediment gases accounted for greater than 80% of the positive buoyancy. Only in deep marsh communities did below-water biomass contribute greater than 20% of the positive buoyancy. Considerably greater than the 8.2% contributed by below-water *Typha* biomass reported for organic flotant in New Brunswick, Canada.

The most surprising result of this survey was the net positive buoyancy values calculated for non-floating emergent marsh communities. Low density of wetland plant tissue, low bulk density of organic sediments and similar sediment matrix conditions allowing the build up of sediment gases were expected to result in a small difference in positive and negative buoyancy. But a net positive buoyancy value should result in flotation. If we assume that buoyancy measurements are accurate (less than a 10% cumulative error in net buoyancy of organic island flotant), the only explanation for these sites not floating when sampled, is some component of negative buoyancy not being included in the buoyancy budget. Because quantification of buoyancy components in this study only extended to the organic/mineral sediment interface, and that mineral sediments have the greatest sinking effect on buoyancy due to their high particle density, I suggest that connectivity to underlying mineral sediments were underestimated.

There are two probable sources of connectivity that occur between organic sediment horizons and underlying mineral sediments, both are related to macrophyte roots. In analyzing cores collected at each site, live roots were often found extending from the surface horizon down into lower horizons. In the case of *Sagittaria lancifolia*, *Peltandra virginica* and *Nuphar luteum* these roots were often over 1.5 meters in length and on occasion extended beyond the core tip. This suggests that roots may extend down through the organic horizons, penetrate mineral sediments and provide a connection to negative components of buoyancy not quantified in this survey. It is also possible that these same roots, even after root senescence, may provide some residual connectivity between the organic/mineral boundary as well as between horizons of the organic sediment. Thus, connection between organic sediments and underlying mineral sediments is not restricted to live roots, but may also result from dead roots transitional across this boundary provided these roots still maintain some structural integrity. If true, this indicates that many non-floating emergent marshes may be poised to be come flotant. However, this does not explain why open water communities that have deep organic sediments do not form flotant. Differences in normalized gas content among sites may provide an explanation.

Significant differences were found between the gas content in open water sites when compared to gas content of organic island flotant and organic marsh flotant. Since gases trapped in the sediment matrix represent the difference between gas produced and gas released, differences found in gas concentration at these communities can result from one of three processes, 1) production rate in one is greater than the other with similar release rates, 2) if gas release rate is greater in one than the other with similar production rates, and 3) if a combination of production and release rates differs between the two communities. Because gas production rates were not measured among these communities, which of these mechanisms is creating the difference in gas content can not be deduced and will require further investigation. However, I hypothesize that the textural differences between open water sites typified by sapric sediments, and organic flotant and emergent flotant, typified by hemic and fibric sediments (see chapter 4) may influence gas release rates. In the case of sapric flocculants sediments, little structural integrity exists and as gas bubbles form it is possible that the bubble can only reach a certain size before positive buoyancy exceeds the cohesion within the matrix releasing the bubble to the surface. This would reduce gas content of the sediment and subsequently the positive buoyancy contributed by sediment gases. In hemic or fibric sediments, or as sapric sediments become more consolidated due to root infiltration, gas bubble size and total number may increase due to cohesion of particles and resistance to release. This would increase overall gas content of the sediment and net positive buoyancy contributions by sediments gases.

Findings of this survey suggest that flotation and formation of vegetative flotant is the result of below-water biomass displacement, and because tissue density of species typically dominant in these communities is not significantly greater than species found on non-floating substrates, species specific growth habit likely provides an equally significant role in the formation and persistence of these communities. Organic flotant buoyancy is principally the result of decomposition gases trapped within the sediment matrix. Contribution of vegetation to buoyancy is minimal, however, the role of vegetation may be significant in restricting non-floating communities from forming flotant by increasing integration of negative components of mineral buoyancy. Vegetation may also be critical in development of hemic, fibric or consolidated sapric sediments that may have a greater capacity for sediment gas storage than unconsolidated sapric sediments typical of open water communities.

Conclusions

This study has shown that components regulating buoyancy on organic flotant differs from that of vegetative flotant. Therefore, conditions that cause the formation of organic flotant likely differ from conditions that cause the development of vegetative flotant. In the case of organic flotant, accumulation of sediment gases within the organic matrix, and connectivity of roots and organic sediment to underlying mineral sediment, were the predominant components/factors regulating buoyancy of these communities. Natural conditions or management decisions that result in increased sediment gas accumulation, or compromise connectivity of roots and sediments, may result in an increased formation of organic flotant. Conversely, if management objectives are to reduce flotant formation, system wide treatment attempts would be optimized if targeted at increasing connectivity of vegetation with underlying mineral sediments and to reduce the accumulation of sediment gases.

Environmental conditions promoting vegetative flotant or management efforts to control it may differ from those that influence organic flotant formation. Vegetative flotant buoyancy was found to be regulated only by the displacement volume of below-water biomass relative to the overall mass of the vegetation. Therefore management of environmental conditions that influence growth and establishment of species prone to vegetative flotant formation would be the optimal way to regulate the formation and extent of these communities.

Whether the objective is management or increased understanding of the processes that regulate successional patterns of flotant formation within a lake, formation of flotant in simplistic terms is the result of a change in net buoyancy conditions from net negative to net positive. However, the biogeochemical and physical processes that regulate components of buoyancy, and the interaction between components of buoyancy to actuate change from net negative to net positive is complex. Further investigations of dynamic changes that occur in buoyancy components under varying environmental conditions, and species specific influences on components of buoyancy and connectivity with mineral sediments will be required before a more mechanistic answer to the formation of flotant can be provided.

CHAPTER 6
HISTORIC EVIDENCE OF FLOTANT COMMUNITIES IN A SHALLOW, WARM-TEMPERATE LAKE

Introduction

A prominent feature of Orange Lake and its fringing wetlands is the occurrence of floating marshes and floating islands. The historic literature makes reference to these communities for the past 130 years. The earliest specific reference to floating communities occurred during the mid 1800s in an account by Major General George A. McCall (1868). In *Letters From the Frontiers* he recounts his first impressions of the vegetation and moving islands of Orange Lake, where he described large floating islands containing trees and noted that local residents indicated these floating communities were common to the lake. The first drawing of floating islands in the lake was in Webb's (1885) *Historical, Industrial and Biographical Florida*. This drawing depicts what appears to be an organic island flotant with woody vegetation, ferns, and vines entangling a small shrub. Since these earliest documentations numerous writers have remarked on the phenomenon of floating islands and marshes in the lake (Warr et al., 1999).

These historical documents provide recent evidence of floating community formation in Orange Lake, however, due to the effects of flotant on vegetative community development (chapter 2), and questions regarding the effect human activity may have had on flotant formation, it was desirable to determine whether evidence of floating wetlands could be found earlier than these historic documents. In addition, if evidence of flotant formation could be determined within the sediment profile, inference regarding spatial extent of flotant formation, sediment transport resulting from flotant and effects of flotant on succession of the lake could be made.

In Florida's Loxahatchee National Wildlife Refuge, a similar technique (Gleason et al., 1980) applied in this study was used to test the hypothesis that flotant acted as nuclei in the initiation of tree island formation. Peat stratigraphy and ^{14}C dating were used successfully in that study to support the hypothesis. In that study, ^{14}C chronology reversals within the sediment profile were explained by the translocation of sediments, via flotant, from one site to another where they subsequently sank (Gleason et al., 1980).

It is hypothesized that sediments dominated by macrophyte plant fragments directly overlying sediments composed of planktonic algal and diatom fragments that also have a discrete boundary between horizons are evidence of flotant sinking. This scenario is suggested since planktonic algal and diatom parent material would be representative of an open water community, and macrophyte sediments representative of flotant, emergent marsh or swamp communities. If a flotant community with established macrophytes were to sink in an area of open water it is likely that the vegetation would die due to an increase in inundation depth. This is expected to form a sediment profile where macrophyte sediments, with no root penetration of the lower sediment horizon, occur directly above sediments indicative of open water communities. If, however, a deep marsh community became established in an area of previously open water, or if a low water event allowed the establishment of macrophyte vegetation, it is more probable that the sediment profile would not show a discrete boundary. Instead, root penetration of the lower layer would result in deposition of macrophyte plant fragments within sediments previously deposited under open water conditions, thus disrupting the abrupt boundary hypothesized to occur between horizons.

Sedimentary evidence of flotant communities may also provide insight into successional development of marsh and swamp communities within Orange Lake. In boreal peatland systems flotant formation has long been associated with lake fringe vegetative succession (More and Bellamy, 1974; Gore, 1983; Vitt and Slack, 1975; Schwintzeri, 1978; Sjors, 1983). In these areas, horizontal expansion and secondary thickening of the mat lead to the infilling of open water and transition of the aquatic system to a more terrestrial community (Kratz and DeWitt, 1988, Wilcox and Simonin, 1988). However, in these temperate and boreal lakes, free floating islands and translocation of sediments as a result of island movement are not frequently noted. In contrast, descriptions of flotant from tropical and subtropical systems often include both flotant attached to the shoreline and free floating islands (Hill et al., 1987; b, 1991b; Goeltenboth, 1982; Southern, 1986; Denny, 1984; Junk, 1970; Gaudet, 1977a). Specifically how these differences in types of flotant may influence vegetative succession can only be hypothesized until cause and effect are tracked over long time periods. However, as evidenced by reversals in ^{14}C dating below tree islands in the northeast Florida Everglades, and as hypothesized in the Okefenokee Swamp based on successional change from herbaceous species to woody after flotant develops (Glasser, 1986; Duever and Riopelle, 1983; Cypert, 1972), significant effects on vegetative succession and landscape-scale heterogeneity may result from flotant formation. Management activities affecting flotant formation may therefore have long-lasting effects on successional processes within the lake.

To address these issues, four objectives were identified: 1) determine whether ^{14}C reversals occur in Orange Lake sediments, 2) determine whether plant fragment analysis and sediment horizon pattern provide evidence of flotant formation, 3) apply findings to test pre-documented evidence of flotant formation in Orange Lake, and 4) relate historic evidence of flotant in the sediment to present day vegetative features in the landscape.

Material and Methods

Site Information

Orange Lake is a shallow, warm temperate aquatic ecosystem located in north central Florida, USA (Figure 1). Lake size ranges from 1,600 to 5,600 hectares depending upon stage. Four events in the past 50 years have lowered water levels 2.5 meters below normal stages. Hydrologic inputs to the lake are from two surface inflows draining catchments to the north and northeast. Outflows include a sinkhole located in the southwest section and overland flow to the southeast. Surface flow to the southeast has been altered several times over the past 70 years, the most restrictive occurring in 1963 when a weir was constructed raising discharge elevation from approximately 52 ft. NGVD to 55.5 ft. NGVD. In 1990 this weir discharge was increased to 57.1 ft. NGVD.

Extensive emergent and floating wetland communities around the lake fringe characterize the lake. Wetlands are dominated by herbaceous species interdigitated by scrub-shrub swamp and tree islands. Lake trophic state since the early 1900s has been described as eutrophic according to diatom species assemblages in the water column and sediments (Brenner and Whitmore, 1996). Sediments are predominantly sapric to hemic organics averaging 1.35 m thick lake wide with some locations having depths exceeding 3.60 m (Danek et al., 1997).

Sample Site Selection

A previous vegetative survey of Orange Lake, conducted by the St. Johns River Water Management District (SJRWMD) and ground truthed in 1995, identified 18 community types (Bryan and Warr, 1998). Using this survey, 10 communities were selected, five floating communities (as delineated by Bryan and Warr, 1998), four bottom rooted emergent marshes (combination of 7 marsh types from Bryan and Warr, 1998), one scrub-shrub swamp (combination of two swamp types from Bryan and Warr, 1998) and one open water community (combination of two open water types from Bryan and Warr, 1998). For each community type, three sample sites were selected in a stratified random manner. Site selection was initially stratified into three lake zones to account for possible spatial variations (Figure 1). Random selections of floating marsh community types were conducted using the SJRWMD's vegetation map. This map was overlaid with a 500 m X 500 m grid, and grid intersects were randomly selected until two sample sites in each community were selected within each of the three lake zones. Grid intersection selection could not be used to determine sampling sites for floating island communities due to their mobility. For floating island communities, a random azimuth heading was taken from the centroid of each lake zone to locate sampling sites. Along each heading, an intercept width of 25 meters was followed until either the desired community or the edge of open water was intersected. When the desired floating island community was found, a random fraction between 0.1 and 0.9 of the total transect distance across the island was calculated to demarcate the placement of the sample quadrat. The 0.0-0.1 and

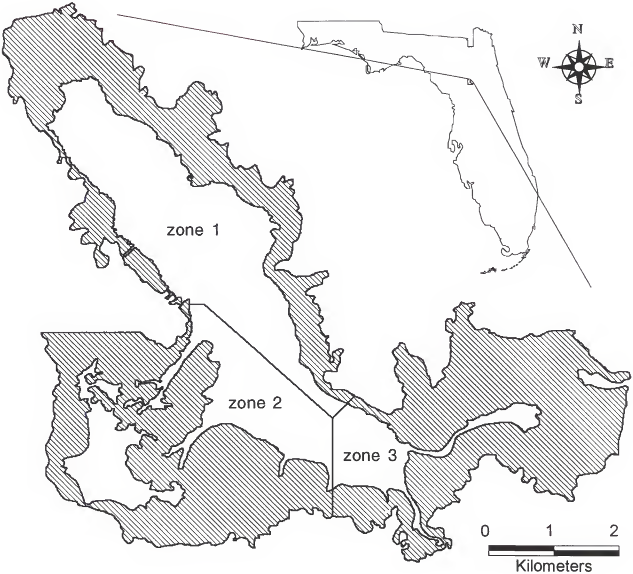


Figure 1. Map of Orange Lake depicting extent of fringing wetland communities (area with diagonal shading) and demarcation of lake zones used in stratified random selection of sampling sites.

0.9-1.0 fraction was rejected to avoid a pronounced edge effect, or placement of part of the sample quadrate in open water. If the desired community type was not intercepted, another heading, 180° away from the open water edge was selected and the process replicated until the desired floating island community was intercepted.

Core Sampling

A single core was collected at a random location within a 2 m^2 quadrat being used for vegetative composition assessment. The coring device used was specifically designed for coring in floating and organic bottom sediments and consisted of a piston corer outfitted with a cutting head (see chapter 3). Cores were collected in an aluminum liner 100 cm long and 15 cm in diameter. Sediments deeper then 1 meter were cored in 1 meter increments. After retrieval liners were capped on both ends and transported in an upright position to the laboratory. Cores were then extruded into a half round PVC trough of equal diameter to the core and cut in half lengthwise with a serrated knife. After exposing the core face, a visual and textural inspection of the core was conducted, noting zones of different color and texture. Zones sufficiently different in either of these parameters were considered different horizons and assigned a letter of the alphabet. A metric tape measure was laid adjacent to the core and adjusted to the depth at which the core was taken in the field. A brief description of each horizon was made noting upper and lower boundary, color based on Munsell soil color charts, texture, and any other significant features.

Plant fragment identification was conducted using both macroscopic and microscopic techniques. Macroscopic identification of easily identified plant fragments within each horizon was noted. This was often assisted by rinsing a portion of the sediment through a #35 sieve to remove decomposed material. Positive identification of fragments was made by comparing unknown samples with a reference collection of preserved samples of known species.

Microscopic plant fragment analysis was conducted using a thin sectioning technique (Mackenzie and Dawson, 1961) modified by Langton and Lee (1965). Intact samples for thin sectioning were collected from the center of each horizon and oriented vertically with respect to *in-situ* position of the core. Sediment samples approximately 25 x 25 x 60 mm in length were extracted and placed in a porous container constructed from 1 mm mesh nylon screening. Samples were then immersed in liquid Carbowax 8000, and maintained at 60°C for 7 days. During this period water soluble Carbowax diffused into interior pore spaces of the sediment sample. Samples were then removed and cooled to room temperature. At room temperature, Carbowax is solid and can be easily handled. Samples were sliced in half, ground and polished before mounting. Castoglas, a thermal setting plastic was used to mount the polished face of the sample to a frosted microscope slide. After mounting, the opposing surface was ground and polished to a thickness of 20-30 μm and covered with a cover slip. Microscopic identification of plant fragments were made at 100X and horizon characteristics made at 25X. A reference collection from living leaf, stem, root, and rootlets of 20 species commonly found at Orange Lake was made for specific fragment characteristics. A collection of partially decomposed tissue of known species and surface horizon sediment from 13 communities on Orange Lake, was used to assist in plant fragment/community type identification.

^{14}C Analysis

Separate peat samples were collected for ^{14}C analysis. A 2-cm-wide sediment slice was collected from the center of each horizon after samples were collected for plant fragment analysis. Samples were dried at 60 °C for 72 hours, and then stored in polyethylene containers at room temperature. After plant fragment analysis was completed and horizon parent material determined to the extent possible, 59 horizons from 16 cores were selected for ^{14}C analysis (All horizons of all cores could not be selected for ^{14}C analysis due to limited funds. Those horizons thought to be most likely to show reversal or characterize the core were selected). Samples of each horizon were sorted removing all recognizable root fragments in an attempt to remove as much introduction of modern carbon into the horizon due to root infiltration. ^{14}C analysis was conducted by the University of Georgia's Center for Applied Isotope Studies. ^{14}C dates were corrected for vegetative carbon isotope fractionation using sample $\delta^{13}C$ ratio. Dates were adjusted using CALIB 3.0 that corrects for atmospheric changes in ^{14}C (Stuiver and Reimer, 1993). This software corrects for variations in atmospheric ^{14}C using a bidecadal calibration dataset determined by tree ring chronology for the last 9,840 years.

Results

The results on peat fragment identification warrant several notes. Identification of plant fragments within the sediment profile require sufficient preservation of morphological characteristics of the plant material so that comparison with known peat samples and live plant tissue will provide positive identification. Quality of plant fragment preservation is dependent upon several factors, all of which relate to the decomposition rate of the plant material. In general, decomposition rates decrease when plant material is submerged below the water surface due to decreased rate of oxygen diffusion through the water column. In addition to oxygen availability, carbon content of the plant material, ratio of carbon to other plant nutrients, and nutrient availability in the surrounding environment can all influence rate of decomposition. Because of these factors, certain plant species are better preserved within the sediment than others are and species found under certain environmental conditions will be better preserved than under other conditions.

As an example, *Nuphar luteum* or *Nymphaea odorata* are typically found in deeper water habitats and have a large component of biomass located below the sediment surface in an anaerobic zone. These two factors reduce the decomposition rate of root and rhizome tissue providing good preservation of plant fragments and an increased likelihood of positive identification of this species. In contrast, species such as *Limnobium spongia* or *Hydrocotyle umbellata* are found at the surface of the water with most, if not all of their biomass within an aerobic water column. The tissues of these species have relatively low C:N values. Therefore, floating herbaceous species are not well preserved, and were rarely identified within the peat sediments during this survey. The point of this particular note is that although a particular species was not detected within the sediment horizon, it does not necessarily mean that this species was not present at the time when that particular horizon was being formed, only that those particular species were not well preserved in the sediment.

Another factor to consider when interpreting this information is the inter-horizon deposition of plant fragments. Unlike analysis of open water lake bottom sediments, which are deposited in relatively discrete layers from bottom to top, vertical penetration of roots and rhizomes into subsurface horizons can result in interhorizon mixing of plant fragments. This was probably most evident at core sites that contained open water sediments overlain by *N. luteum* or *N. odorata* peat horizons. These two species have a considerable vertical component to below-ground morphology that resulted in roots from upper horizons penetrating into subsurface sediments. In this case, the point being that not all plant fragments identified at a particular horizon may have been present during the initial deposition of that horizon, but instead may have been the result of secondary interhorizon deposition.

These points are not intended to detract value of information available from the plant fragments analysis of this study, only to clarify the presentation and interpretation of this information.

Of the 16 cores selected and analyzed, only two stratigraphies will be reported in this results section. Plant fragment identification, ^{14}C analysis and core horizon characteristics of all 30 cores can be found in the Chapter 6 appendix.

Core FMc-1A at the time of sampling was classified as an organic marsh flotant community (Figure 2). Vegetative composition consisted of 13 species dominated by *Bidens laevis, Decodon verticillatus, Limnobium spongia, Polygonum densiflorum* and *Cicuta mexicana*. The surface horizon was a complex of live and dead root fragments with little decomposed organic sediments. Horizon B was composed of a composite of plant fragments with no dominant species. Dominant plant fragments of horizons D and E could not be identified. Secondary fragments found in the D horizon were similar to those found in the B horizon. ^{14}C dating of the E horizon indicates the age of sediments at the horizon midpoint was 560 ± 60 year before present

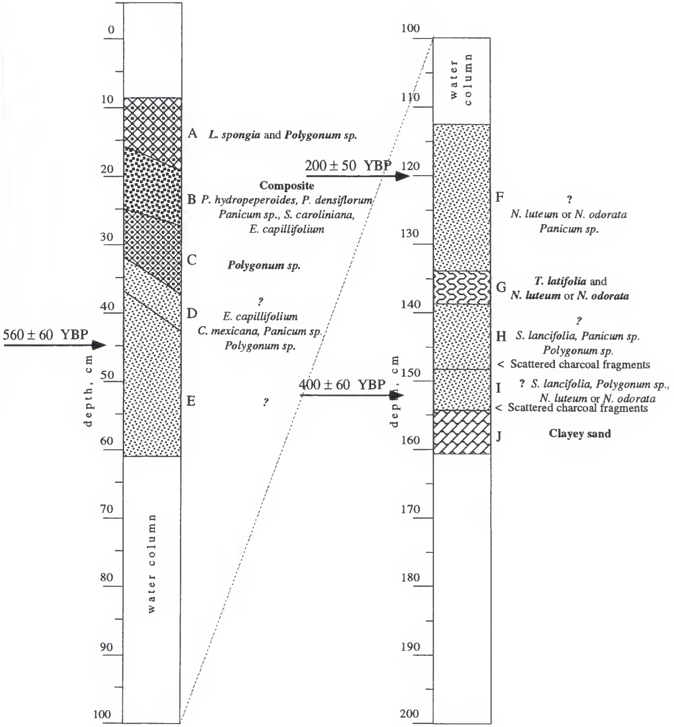

0
10
20
30
40
50
60
70
80
90
100
depth, cm
water column
A *L. spongia* and ***Polygonum sp.***
Composite
B *P. hydropeperoides, P. densiflorum,*
Panicum sp., S. caroliniana,
E. capillifolium
C ***Polygonum sp.***
D ?
E. capillifolium
C. mexicana, Panicum sp.
Polygonum sp.
E ?
560 ± 60 YBP
200 ± 50 YBP
400 ± 60 YBP
100
110
120
130
140
150
160
170
180
190
200
depth, cm
water column
F ?
N. luteum or *N. odorata*
Panicum sp.
G ***T. latifolia*** and
N. luteum or ***N. odorata***
?
H *S. lancifolia, Panicum sp.*
Polygonum sp.
< Scattered charcoal fragments
I ? *S. lancifolia, Polygonum sp.,*
N. luteum or *N. odorata*
< Scattered charcoal fragments
J **Clayey sand**

Figure 2. Peat stratigraphy of core FMc-1A, organic base marsh flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon. ^{14}C dates indicate years before 1950.

(international convention indicates 1950 as the reference for "years before present" (YBP)). A 55 cm free water zone existed between the floating portion of the core and the surface horizon of the bottom sediment. Date of horizon F was 200 ± 50 YBP. No identifiable plant fragments dominated horizon F although *N. luteum*, *N. odorata* and an unknown species of *Panicum* were present. *Typha latifolia* and *N. luteum* or *N. odorata* plant fragments dominate horizon G. Dominant fragments in horizons H and I could not be identified although fragments of *S. lancifolia*, *Polygonum* sp., *N. luteum* or *N. odorata* and an unknown species of *Panicum* were present. Also noted at the base of each of these horizons were scattered charcoal fragments. The age of the bottommost horizon of this core was 400 ± 60 YBP.

Core SSa-3A was collected in the center of a shrub scrub community dominated by *Salix caroliniana* (Figures 3a and 3b). The surface horizon at this site was also dominated by leaf litter and live roots of *S. Caroliniana* with secondary contributions by *Peltandra virginica*. Plant fragments in Horizons B and C were composites of several species with root fragments of *S. Caroliniana* also present. In horizon D, no dominant plant fragment was identified, however, several well preserved and intact leaves of *Myrica cerifera* were found at the base of this layer directly above a band of charcoal fragments. Horizons E and F were composed of *N. luteum* or *N. odorata* and *Polygonum* and an unidentified *Panicum* species. Horizons G-I were dominated by *Sagittaria lancifolia.* In horizon I, *S. lancifolia* was dominant with secondary plant fragments of *N. luteum* and *N. odorata* also present. Horizon K was predominantly deposited under open-water conditions having a majority of sediment particles composed of planktonic diatom species. This horizon also had fragments of *N. luteum* rhizome with remnant petiole abscission scars and recent root fragments of *S. lancifolia*. Horizon L sediment

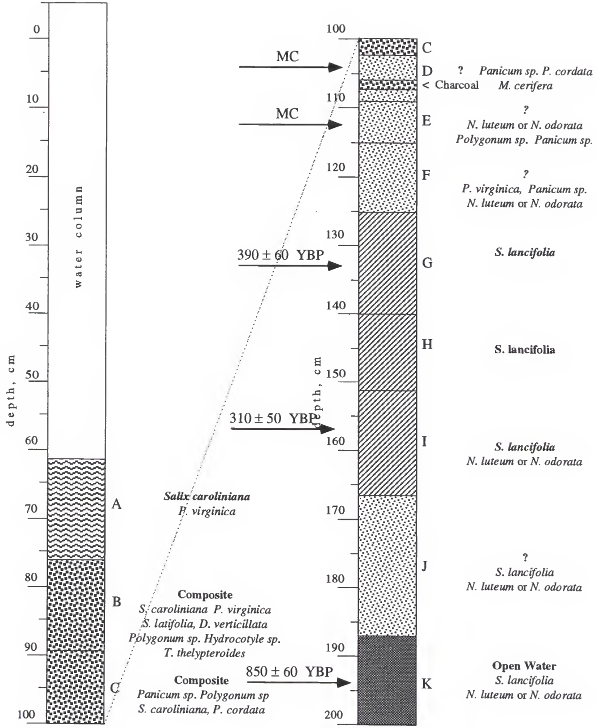


Figure 3a. Peat stratigraphy of core SSa-3A, scrub-shrub swamp (0-200 cm depth). Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon. ^{14}C dates indicate years before 1950.

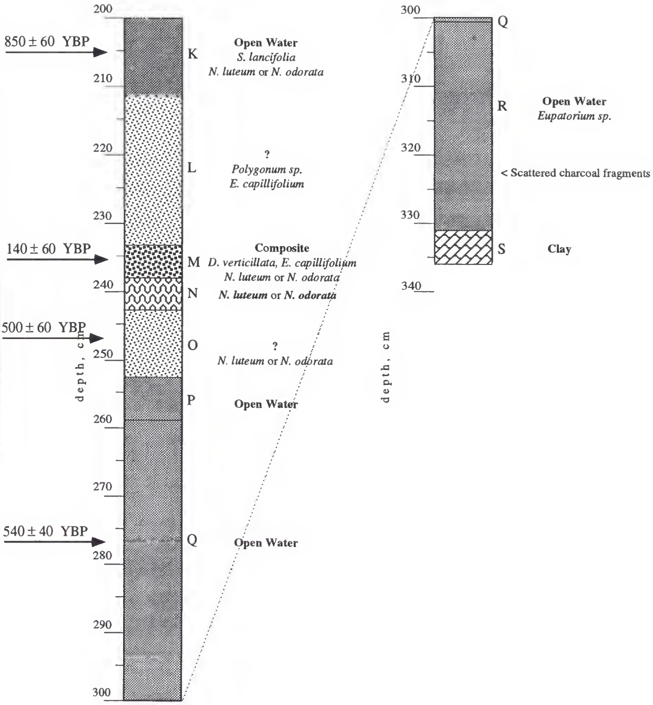


Figure 3b. Peat stratigraphy of core SSa-3A, scrub- shrub swamp (200-335 cm depth). Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon. ^{14}C dates indicate years before 1950.

particles were not dominated by fragments indicative of open water deposition and contained fragments of an unknown *Polygonum* species and fragments of *Eupatorium capillifolium*. Horizon M was considered a composite layer composed of *D. verticillatus*, *E. capillifolium* and *N. luteum* or *N. odorata*. Horizon N was dominated by *N. luteum* or *N. odorata* plant fragments. *Nuphar luteum* or *N. odorata* fragments were also found in the O horizon, but the dominant plant fragment could not be determined. The bottom three horizons of this core (P, Q, R) were all dominated by planktonic diatom species with little or no macrophyte fragments noted. Only in horizon R were several fragments of *E. capillifolium* noted although these scattered throughout the horizon and did not occur as a discrete layer. Charcoal fragments were also noted near the base of this horizon.

^{14}C dating of core SSa-3A indicates one prominent reversal between the date of horizon K, 850 ± 60 YBP (206 cm) and that of horizon M 140 ± 60 YBP (236 cm). Attempts to date horizon D and E indicate sediments in these horizons were deposited after 1950. Another reversal may exist between horizons G and I, but due the error associated with these dates, statistically these dates are indistinguishable and therefore an actual reversal may not have occurred. Two other dates within the profile indicate horizon O is 500 ± 60 YBP (247 cm) and horizon Q is 540 ± 40 YBP (275 cm).

Discussion

The two cores provide evidence to support objectives of this study. Core FMc-1A represents a snapshot of conditions prior to flotant sinking and becoming a contiguous record in the sediment profile. ^{14}C date of the bottom horizon of the floating organic sediment (45 cm) is older then the uppermost horizon of the non-floating sediment (120 cm). This supports the hypothesis that reversals in chronology can occur as a result of translocation. If this flotant were to sink, a record of the flotant presently at the site would be saved in the sediment.

Surface horizons of the floating portion of core FMc-1A provide evidence of the type of plant fragments preserved in sediments formed under floating substrate. As noted in the results section, herbaceous species are easily degraded and are not well preserved, however, species such as *Polygonum demersum, Eupatorium capillifolium, Cicuta mexicana, Decodon verticillatus* and *Thelypteris Thelypteroides* were often associated with flotant and are well preserved in the sediment. This is evident in the upper two horizons of core FMc-1A. In addition, species composition on flotant was rarely monodominant, and often had the highest species diversities of all vegetative communities on the lake (see chapter 2). In contrast, vegetation in emergent marsh communities is often monodominant and therefore typically only has one or possibly two plant fragments identified in the remnant horizon. Differences in species composition and species richness of a horizon are therefore indicative of flotant origin and were important in interpretation of other cores.

Depth to the mineral profile of core SSa-3A was greater than some of the open water community sites investigated, yet vegetation at this site was dominated by scrub-shrub species that require non-inundated conditions for initial establishment. Sediment composition of the bottom most horizons also indicated that the site was historically an open water community. However, it is not apparent how a swamp community became established in this previous open water community where mineral sediment depths are greater than many open water sites of the lake. Several features within the stratigraphy and ^{14}C chronology lead me to believe the present scrub-shrub community may be in part the result of flotant.

It appears that at least three organic flotant communities sank in what historically was an open water community. The first of these sinking events took place within the past 250 years. This is based on the ^{14}C date, plus associated error, of the M horizon. The composite plant fragments noted in horizon M identify the surface horizon of the first island. It is also likely that horizons N and O were also associated with the first flotant sinking. This is deduced since no infiltration of roots into the P horizon was noted. Without infiltration of lower horizons by *N. luteum* or *N. odorata* it is likely that formation of these horizons would have had to occur off site.

The second flotant community deposited at the site is evident in horizon K. This is deduced by the age of the sediments, and the integration of *N. luteum* or *N. odorata* plant fragments with open water sediments. Sediment and plant fragment composition of horizon K is characteristic of organic flotant islands found floating in present day open water areas of the lake (see chapter 6 appendix and chapter 4).

The last island flotant influencing the site that can be verified by evidence in the profile are horizons B and C. Plant fragments of these horizons are indicative of flotant communities. Two of these species *D. verticillatus* and *T. thelypteroides* were only found on flotant communities. Although it is possible that these species and subsequent plant fragments found in these horizons could have occurred as the result of a low water event, the thickness of these horizons would have required an extended low water event to occur. Modern carbon found within the D horizon suggests that the B and C horizons have been deposited more recently than 1950, and therefore an extended drought condition would have had to occur during the past 50 years. Hydrologic data does not indicate a drought duration longer than 2 years occurring since 1942 (Warr et al., 1999).

A more likely explanation is that horizon C and B formed under floating substrate conditions. During this formation period, the 60 cm water column presently above the substrate was likely between horizons C or D and horizon E (similar to core FMc-A1). At some point, conditions sufficient to support germination and growth of *S. caroliniana* occurred and resulted in the establishment of woody species on the flotant. As this woody species grew, net positive buoyancy on the site became compromised causing the flotant to sink. However, once *caroliniana* becomes mature it can tolerate increased inundation depths, and therefore survived after the flotant sank.

Conclusions

These two cores, identified earlier in this chapter, provide plausible evidence of prehistoric flotant formation on Orange Lake. This evidence was supported both by reversals in ^{14}C dates similar to findings in the Loxahatchee National Wildlife Refuge (Gleason et al., 1980) and plant fragment associations similar to recalcitrant species found on present day flotant. Although spatial extent of the historic occurrence and deposition of flotant communities in Orange Lake is difficult to assess, findings support the hypothesis that flotant formation can and has influenced vegetative succession in some areas of the lake. Mass mobility and discrete deposition of sediments resulting from flotant translocation is uncharacteristic of sediment deposition occurring under open water or emergent marsh/swamp conditions. If evidence identified in these cores is more universal in lake sediments and flotant plays a significant role in the development of scrub-shrub communities as well as other vegetative succession, implications for landscape scale structural heterogeneity and wild life habitat (Sieving and Schaefer, 1998) could be significant.

CHAPTER 7
TEMPORAL AND SPATIAL DYNAMICS OF FLOTANT IN A SHALLOW, WARM-TEMPERATE LAKE

Introduction

When considering vegetation change, it is typical to think of successional changes in species composition over time, or in response to disturbance such as fire, frost or drought (van der Valk and Davis, 1978; van der Valk, 1982; Niering, 1989; Siegley et al., 1988; Odum, 1982). It is less common to think of vegetative change resulting from the relocation of a vegetative community to another point in space at a different point in time. This feature is one of the more fascinating and dynamic aspects of island flotant formation. Flotant, defined as vegetative and or sediment that floats at or near the water surface, can form floating marshes that are attached along the shoreline (marsh flotant) or floating islands (island flotant) that are surrounded by water and move in response to wind or water currents. Formation of flotant is the result of gases that accumulate within organic sediments (Hogg and Wein, 1988) or vegetation that is adapted to colonize open water areas (Gopal, 1987). On occasion, flotant will form initially as islands that become established in open water areas with no initial shoreline attachment (Haraguchi, 1991b; Hogg and Wein, 1988). In most cases, however, island flotant forms initially as marsh flotant attached to the shoreline. Horizontal expansion of the marsh flotant over time increases exposure to wind and waves and eventually portions of the marsh can break loose forming island flotant (Lawson, 1967; Junk, 1970; Southern et al., 1986; Reid, 1952).

Island and marsh flotant has been described in many parts of the world and can play a significant role in the development of wetland and aquatic ecosystems (Wigham et al., 1987). In boreal peatlands it is hypothesized that terrestrialization of peatland lakes is in part the result of horizontal expansion and secondary thickening of marsh flotant (Kratz and DeWitt, 1986; Wilcox and Simonin, 1988). In southeastern United States peatlands translocation of sediments as a result of flotant formation and movement have been shown to act as nuclei in the initial establishment of tree island communities, a prominent feature of the landscape (Glasser, 1986; Gleason, 1980; Gleason and Stone, 1994). Island flotant in Lake Malawi, Africa has been shown to provide a dispersal mechanism for cryptic and littoral zone fish species. As islands leave one shoreline and traverse the lake over open water, fish use the island as refugia and are more safely transported across and thought to be able to increase gene flow between disjunct populations (Oliver and McKaye, 1982). Mobility of island flotant in some areas can also become a significant nuisance and economically damaging. Vegetative and organic rafts of island flotant in Lake Victoria (Terry and Minto, 1970), the Upper Nile (Denny, 1984) and Indonesia (Goelenboth, 1982; Little, 1969), to name a small fraction, can cause problems with navigation and in some instances can completely block ports for commercial trade. Marsh flotant formation has been considered undesirable to fisheries production in some lake management programs due to low oxygen conditions below the flotant (Alam et al., 1996; Moyer et al., 1995).

Orange Lake, located in north central Florida has a history of flotant formation dating to the mid 1800's and these communities are still a prominent feature of the lake.

Similar to the systems mentioned above, mobility of island flotant in the lake creates navigation and access problems to boaters, and marsh flotant is a concern to fisheries managers. However, marsh and island flotant also appears to contribute significantly to vegetative species richness (see chapter 2), successional development (see chapter 6) and wildlife habitat (Sieving and Schaefer, 1997) of the lake ecosystem. In 1990-1991 drought conditions stimulated discussion to regulate water level on the lake to reduce the extent and duration of low water events. In evaluating possible effects of water level intervention, a better understanding of island and marsh flotant communities was necessary. As part of that investigation temporal and spatial mobility of flotant was desired. Mobility of individual island flotant was conducted using radio telemetry and visual observations in a study conducted in 1997 (Seivings and Schaefer, 1997). That study concluded island flotant mobility was highly variable with some islands traveling a minimum of 21 km during a 90 day period while other islands showed no movement during the same period. In this study a broader observation of island flotant was conducted with the following objectives: 1) to characterize island flotant movement, 2) to determine the area of flotant that is presently mobile, 2) determine if there are areas of the lake where flotant tends to originate or collect, and 3) determine recent change in vegetated and open water areas of the lake.

Materials and Methods

Study Site

Orange Lake is a shallow, warm temperate aquatic ecosystem located in north central Florida, USA (Figure 1). Lake size ranges from 1,600 to 5,600 hectares depending upon stage. Four low water events in the past 50 years have occurred lowering water levels 2.5 meters below normal stages. Hydrologic inputs to the lake are from two surface inflows draining catchments to the north and northeast. Outflows include a sinkhole located in the southwest section and overland flow to the southeast. Surface flow to the southeast has been altered several times over the past 70 years, the most restrictive occurring in 1963 when a weir was constructed raising discharge elevation from approximately 52 ft. NGVD to 55.5 ft. NGVD. In 1990 this weir discharge was increased to 57.1 ft. NGVD.

Extensive emergent and floating wetland communities around the lake fringe also characterize the lake. Wetlands are dominated by herbaceous species interdigitated by scrub-shrub swamp and tree islands. Lake trophic state since the early 1900's has been described as eutrophic according to diatom species assemblages in the water column and sediments (Brenner and Whitmore, 1996). Sediments are predominantly sapric to hemic organics averaging 1.35 m thick lake wide with some locations having depths exceeding 3.60 m (Danek et al., 1997).

Aerial Photography

Aerial photographs of Orange Lake were taken June 13, July 23 and September 24, 1996. Timing of all flights was between 0900 and 1100 hours. Photographs were taken using a medium format Fujicolor 100 ASA film and printed in real color on 13 x 13 cm Fuji photo paper. A Ciro-flex camera was used affixed with a Wollensak 85 mm lens and remote shutter release. Photographs were taken at an altitude of 1500 meters providing ground coverage for each photo of approximately 1 km^2. Photos were taken from a Cessna 152 aircraft with a camera platform attached to the right side door

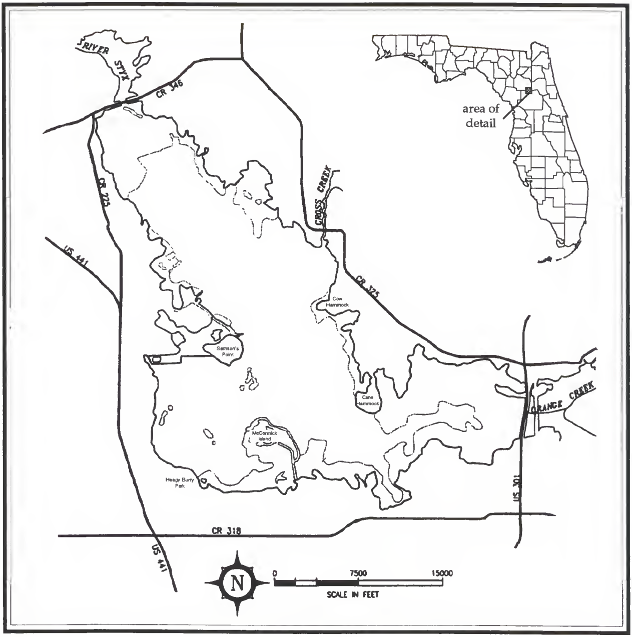


Figure 1. Map of Orange Lake located in southeastern Alachua county.

allowing for in-flight adjustments of shutter speed, f/stop and film reloading. The camera mount was equipped with an X and Y level indicator allowing for photographs to be taken when the camera was within 3° or less of perpendicular orientation to the ground.

Photographic Interpretation

The principal objective of this portion of the survey of floating wetlands was to analyze spatial and temporal dynamics of these communities in Orange Lake. Because of the difficulty of using aerial photographs to interpret between floating status of several vegetated communities (bottom rooted emergent marsh and shrub swamp communities with several meters of floating peat), the focus of this effort was on floating island communities and those vegetative communities that were adjacent to areas of open water.

Photographs were scanned at a resolution of 270 dots per inch (dpi) using a TwiainScann II SP Mustek scanner, and imported into Adobe Photoshop 4.0 where individual images were rectified to 1994 Digital Orthophoto Quarter Quads taken by the United States Department of Agriculture (USDA). Once rectified, individual photographs were compiled to generate three separate coverages of Orange Lake based on the three dates in which the photographs were taken. The compiled coverages and the USDA base map were then interpreted and classified into one of three coverage types; open water, fringing deep marsh and floating/emergent wetland. Using the absence of values within the red band under model RGB color, most areas of open water could be easily selected by the computer using the select command. Sensitive settings of the selection tool ranged from 5 to 10 depending upon solar reflectance at the water surface, this was most variable in the 1994 USDA images. Interpretation of deep marsh communities adjacent to open water areas was more problematic, especially in the later photographic coverages, when degradation of *Nuphar luteum* due to Fluridone application was most prevalent. Ground-truthing several weeks after photos were taken and comparison with photographs of intact stands of *N. luteum* in the May photographic coverage were used to accurately interpret this community. This community was then recoded with a common color code and identified as fringing deep marsh community. Using the invert command from the color range selection tool in Photoshop 4.0 and selecting areas classified as open water or fringing deep marsh community, all areas not previously interpreted and recoded were classified as floating/emergent wetland.

After interpretation and recoding, images were imported into MapFactory 2.1.1. Resolution in MapFactory of these images was 2 m^2. In MapFactory, an area of each coverage type was determined in hectares and maps produced for the four survey dates. Three additional maps were generated which indicated areas of change. Overlaying maps of adjacent survey dates and recoding areas of change with a different color created these maps.

Spatial and Temporal Analysis

Analysis of the three temporal photographs relies on one principal assumption: that changes from open water to vegetated or vegetated to open water categories at a given location represent the formation or subsidence of flotant, or the movement of flotant into or away from a particular site. On a larger, lake wide scale, change in aerial coverage of open water is assumed to represent a net increase in flotant formation (decreased open water and deep water community coverage) or a net decrease in floating wetland formation (increase in open water and deep marsh coverage).

Based on these assumptions three comparisons of photographic coverages were made, January 1994 with June 1996, June 1996 with July 1996, and July 1996 with September 1996. Combining these temporally different maps resulted in seven possible coverages, 1) unchanged open water, 2) unchanged deep marsh community, 3) unchanged Floating/Emergent Wetland, 4) open water to Floating/Emergent Wetland, 5) Floating/Emergent Wetland to open water, 6) deep marsh to open water and 7) deep marsh to Floating/Emergent Wetland. Surface area coverages of each of these categories were also compiled providing data for determination of total net change in area coverage of flotant.

Results are reported separately for the three cover types interpreted between January 22, 1994 and September 24, 1996. For each cover type, aerial extent and changes in community cover are reported. In an effort to provide a high level of detail, analysis and the creation of community coverage maps was conducted by separating the lake into seven sectors; North, East(north), East(south), PG Run, South, McIntosh Bay and West (Figure 2). Demarcation of these sectors utilized prominent features of the lake/upland boundary for separation. (Maps indicating the aerial extent of the three coverage types, and change in cover between survey dates, can be found in Appendix E. Maps indicating change in community cover type for each sector and between the four survey dates can be found in Appendix I. Lake stage data between November 1993 and January 1997 can be found in Figure 3. This graph also identifies the lake stage during each of the four aerial survey dates.

In the interpretation of aerial photographs no distinction was made between flotant communities and emergent wetland communities. These two community types were collectively identified as Floating/Emergent Wetland community areas. It is my assumption that any change in the Floating/Emergent Wetland community area is primarily due to the formation, movement, or subsidence of Floating Wetland communities rather than Emergent Wetland communities.

Results

Lake Wide Coverage and Change in Floating/Emergent Wetland Community Area.

Floating/Emergent Wetland community area in Orange Lake decreased between January 22, 1994 and September 24, 1996 (Figure 4). The amount of loss in Floating/Emergent Wetland community area was greatest between the survey dates of January 22, 1994 and June 13, 1996 (-140 ha)(Table 1, Figure 5). The reduction in Floating/Emergent Wetland community area during these first two sampling dates was principally the change of Floating/Emergent Wetland community area to Open Water (134 ha), but was also due to a change in Floating/Emergent Wetland community area to fringing Deep Marsh community (-5.6 ha)(Figure 6). Decline in Floating/Emergent Wetland community area was also evident between the survey dates of June 13 and July 23, 1996 (-4.0 ha) and July 23 and September 24, 1996 (-4.4 ha)(Figure 4). The principal source of decline in Floating/Emergent Wetland community area during these dates was a conversion to Open Water area (-15.9 ha and -9.9 ha, respectively). However, there was also a slight increase of 64 hectares in Floating/Emergent Wetland community area that offset declines noted above. These increases resulted from a change in fringing Deep Marsh community area to Floating/Emergent Wetland community area.

Floating/Emergent Wetland community area that changed location (representing Floating Wetland communities) can be estimated by combining that area which formed or

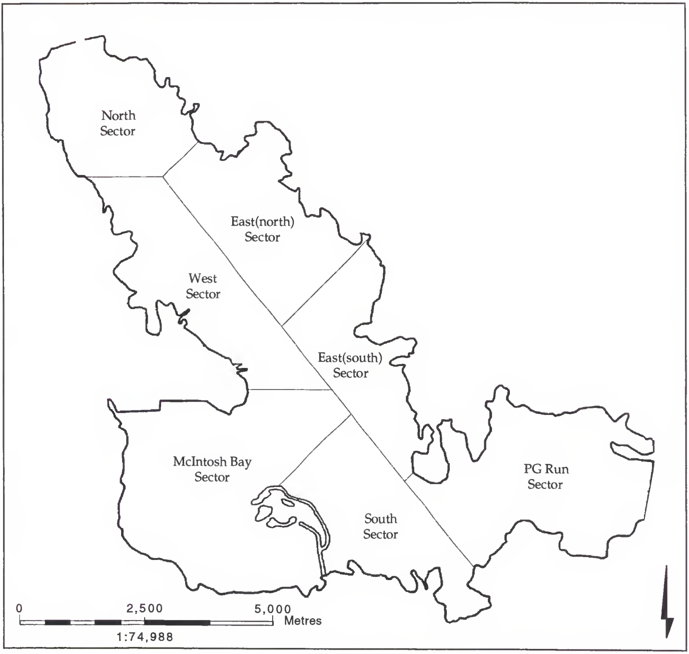


Figure 2. Map of lake sectors and their boundaries used to develop coverages in this survey. All boundary lines are at 45° or 90° angles with the exception of the central boundary line which has an azmith of 308.7° true north.

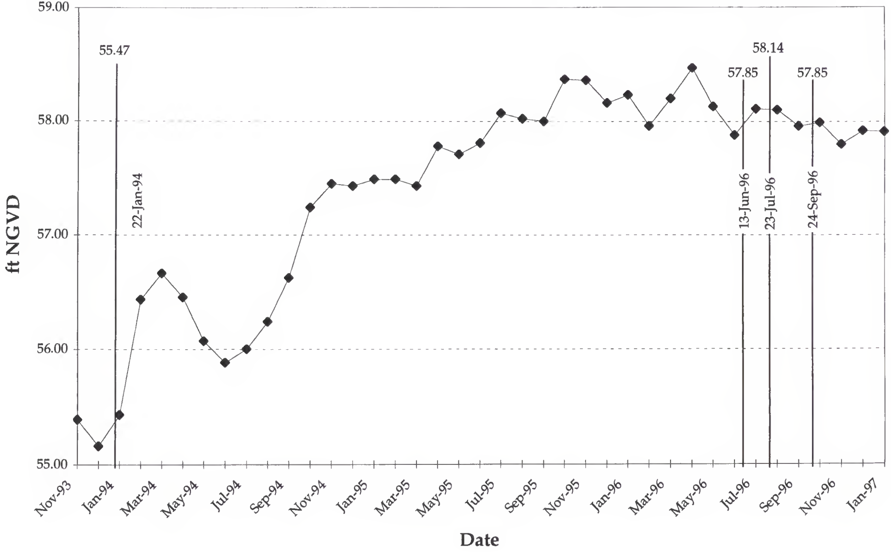


Figure 3. Average monthly lake stage between November 1993 and January 1997 (SJRWMD). Aerial surveys are identified by date and vertical line. Lake stage for the day of the survey is indicated at the top of the vertical line.

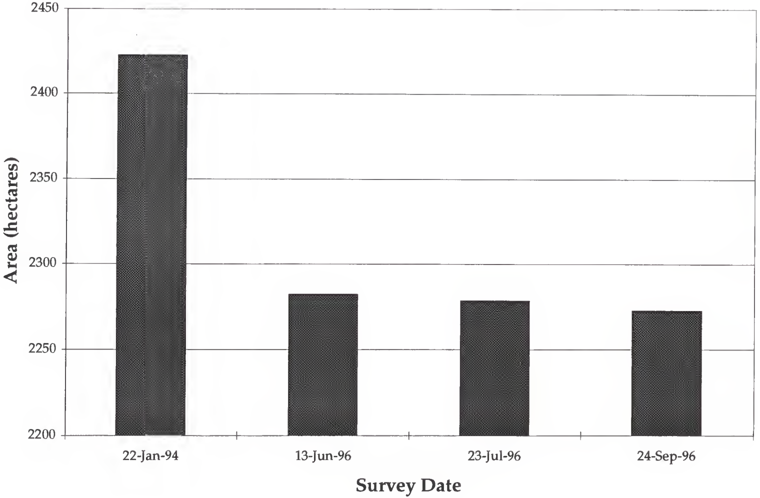


Figure 4. Lake wide coverage of Floating/Emergent Wetland community area on four dates between January 22, 1994 and September 24, 1996.

Table 1. Change in coverage of Floating/Emergent Wetland community area over four survey periods between January 22, 1994 and September 24, 1996.

	Change in Area (hectares)		
Lake Sector	January 22, 1994 to June 13, 1996	June 13, 1996 to July 23, 1996	July 23, 1996 to September 24, 1996
North	-16.7	-1.6	2.0
East(north)	-27.9	1.5	3.0
East(south)	-25.8	4.3	-6.5
PG Run	-17.4	-2.1	1.1
South	-7.0	-2.2	-3.2
McIntosh Bay	-32.5	-1.6	-1.6
West	-13.0	-2.0	-0.7
Lake Wide Change	-140.1	-3.8	-5.9

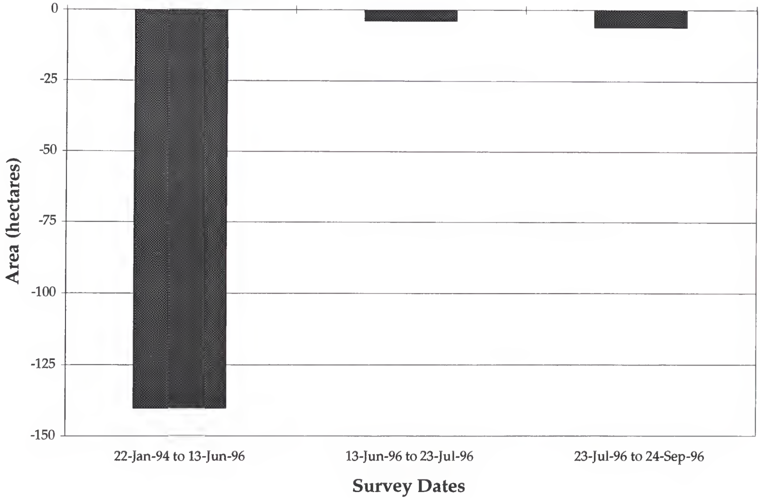


Figure 5. Change in lake wide coverage of Floating/Emergent Wetland community area between the four dates surveyed from January 22, 1994 to September 24, 1996.

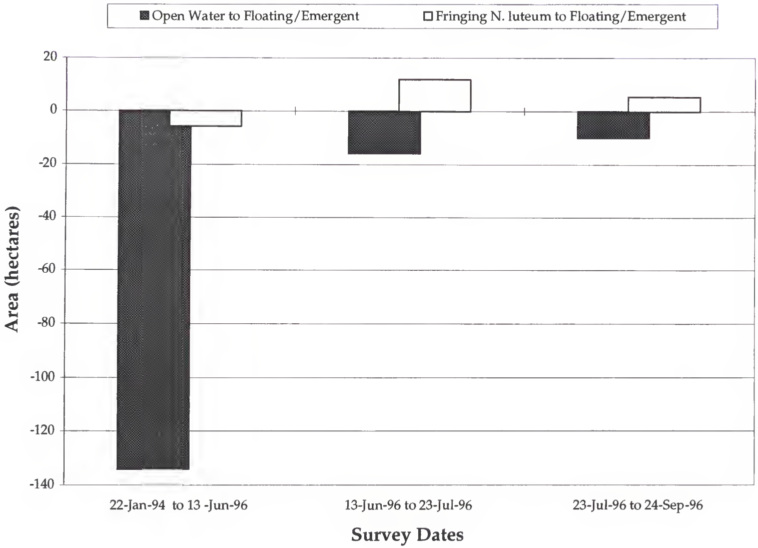


Figure 6. Sources of change in lake wide Floating/Emergent Wetland community area between the four dates surveyed. The value of Open Water to Floating/Emergent represents the net value Open Water to Floating/Emergent area minus Floating/Emergent to Open Water area. The value of Fringing *Nuphar luteum* to Floating/Emergent represents the net value of Fringing *Nuphar luteum* to Floating/Emergent area minus Floating/Emergent to Fringing *Nuphar luteum* area.

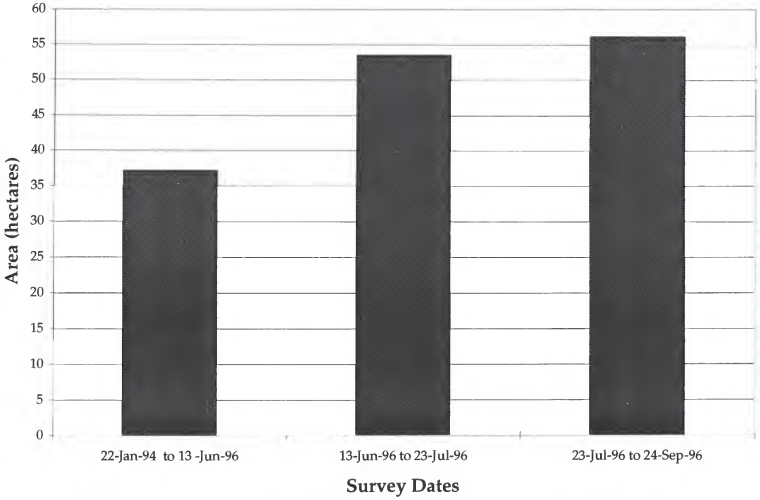


Figure 7. Lake wide area of Floating/Emergent Wetland community estimated to have translocated or formed during the survey dates identified. These values represent the area of Floating/Emergent Wetland community which became established in areas previously identified as Open Water or Fringing *Nuphar luteum* communities.

changed from Open Water and fringing Deep Marsh communities to areas of Floating/Emergent Wetland communities. This estimate takes into account net movement, subsidence or formation that occurred between the dates surveyed. This value however is only a comparison between two points in time and does not represent any movement, formation or subsidence that did not result in a net change in the community area or position. Therefore, the values calculated for movement and formation of Floating/Emergent Wetland community area are likely conservative and underestimate the true dynamic extent of this community on Orange Lake. With this understanding, the lake wide formation and movement determined for Floating Wetland communities between the survey dates of January 22, 1994 and June 13, 1996 was 37.1 ha. This value increased to 53.5 ha between June 13, 1996 and July 23, 1996, and to 56.1 ha between July 23, 1996 and September 24, 1996 (Figure 7). Communities that formed floating wetlands or moved between January 22, 1994 and June 13, 1996 were principally fringing Deep Marsh community area. This was not true between June 13, 1996 and September 24, 1996 when principal movement and formation occurred in Open Water areas (Figure 8). However, a portion of the movement and formation of Floating Wetland communities during the 1996 survey dates did occur in fringing Deep Marsh community area and had areas of change which were approximately equal to (22.0 ha June 13 to July 23, 1996) and slightly less than (14.7 ha July 23 to September 24, 1996) the area(22.2 ha) between January 22, 1994 and June 13, 1996.

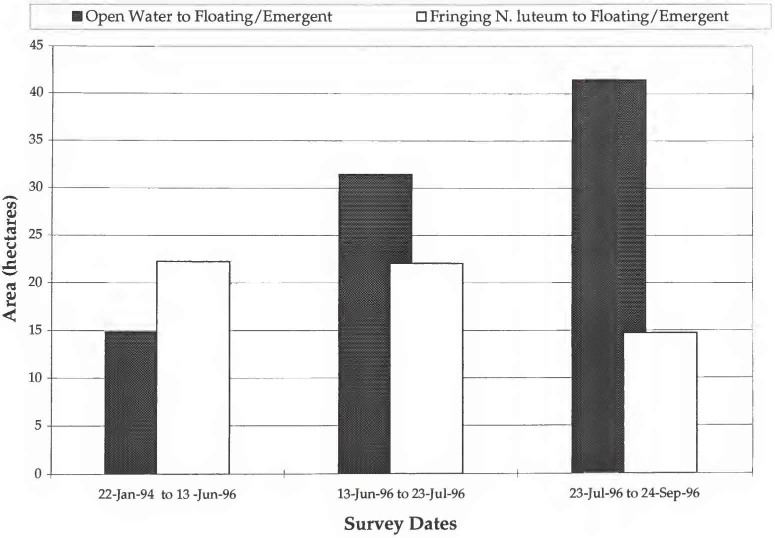


Figure 8. Lake wide sources of Floating/Emergent Wetland community formation and movement. Values represent area of change from either Open Water or Fringing *Nuphar luteum* community into Floating/Emergent Wetland community area either by movement of floating islands or formation of a floating wetland.

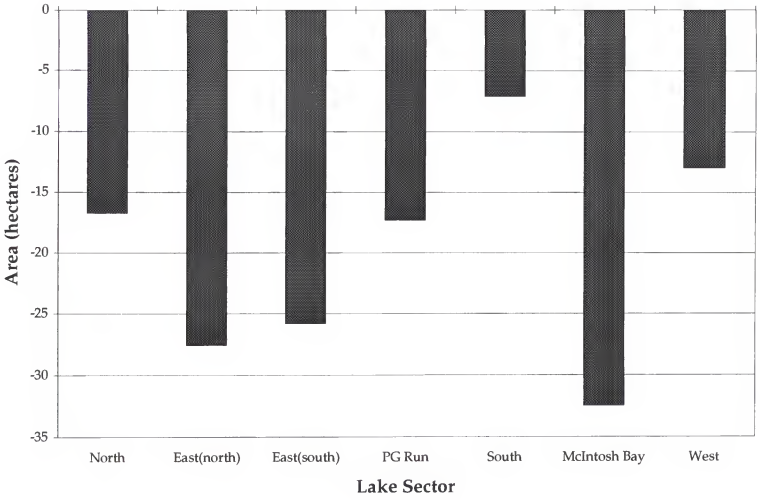


Figure 9. Change in Floating/Emergent Wetland community area in each lake sector between January 22, 1994 and June 13, 1996.

Change in Floating/Emergent Wetland Community Area between January 22, 1994 and June 13, 1996.

Lake sector change between January 22, 1994 and June 13, 1994 resulted in a decline of Floating/Emergent Wetland area by 139.7 ha. The lake sector having the greatest decline during this survey period was McIntosh Bay (-32.5 ha), with East(north) and East(south) Sectors also having large declines of -25.2 ha and -25.8 ha, respectively (Figure 9). The sector that had the smallest decline in Floating/Emergent Wetland community area was the South Sector, with a decline of 7.0 ha. In all lake sectors, Open Water community primarily replaced areas of Floating/Emergent Wetland community. The range of this change was from -29.6 ha in the McIntosh Bay Sector to -8.4 ha in the South Sector (Figure 10). Replacement of Floating/Emergent Wetland community area by fringing Deep Marsh community was a much smaller component, and ranged from 2.9 ha in the McIntosh Bay Sector to 0.1 ha in the West Sector. Several sectors during this survey period had a net increase in Floating/Emergent Wetland community due to their formation in areas of fringing Deep Marsh community. These sectors included the North sector (0.5 ha) and the South sector (1.4 ha).

Movement and formation of floating wetlands during the survey period of January 22, 1994 to June 13, 1996 was 37.1 ha lake wide. The greatest net movement and/or formation of Floating/Emergent Wetland community area were 17.4 ha, and occurred in the McIntosh Bay Sector (Figure 11). The lake sector with the smallest amount of Floating Wetland community movement and/or formation was the West Sector (1.6 ha). Movement and formation of Floating Wetland communities was most evident in areas of fringing Deep Marsh community. Only the PG Run Sector and the South Sector had a greater area of Floating Wetland community movement and formation in areas of Open Water (Figure 12).

Change in Floating/Emergent Wetland Community Area between June 13, 1996 and July 23, 1996.

A lake wide net decline of 4.01 ha in Floating/Emergent Wetland community area occurred between June 13, 1996 and July 23, 1996. As opposing component in this net decline was the formation of 11.9 ha of Floating Wetlands formed due to the loss of Fringing Deep Marsh. However, 15.9 ha of Floating/Emergent Wetland community resulting in the net decline of 4.0 ha (Figure 6). Changes in Floating/Emergent Wetland community area were most evident in the East(South) Sector with an increase in area of 4.4 ha, and in the South and West Sectors with decreases of 2.1 and 2.1 ha, respectively (Figure 13). A decline in Floating/Emergent Wetland community area resulting from change to Open Water community was greatest in the McIntosh Bay Sector (-6.6)(Figure 14). Increases in Floating/Emergent Wetland community area, which replaced previously Open Water community area, were found in the East(south) sector, (1.5 ha) (Figure 14). Fringing Deep Marsh community conversion change to Floating/Emergent Wetland community, increased the Floating/Emergent Wetland community area by 0.1 ha in the West Sector and by 5.0 ha in the McIntosh Bay Sector (Figure 14). The PG Run Sector was the only sector of the lake where the decrease in Floating/Emergent Wetland Community was a result of a change of Floating/Emergent Wetland community into fringing Deep Marsh community (-0.2 ha).

Movement and/or formation of Floating/Emergent Wetland community areas lake wide during this survey period was estimated at 53.5 ha. Change in cover type to

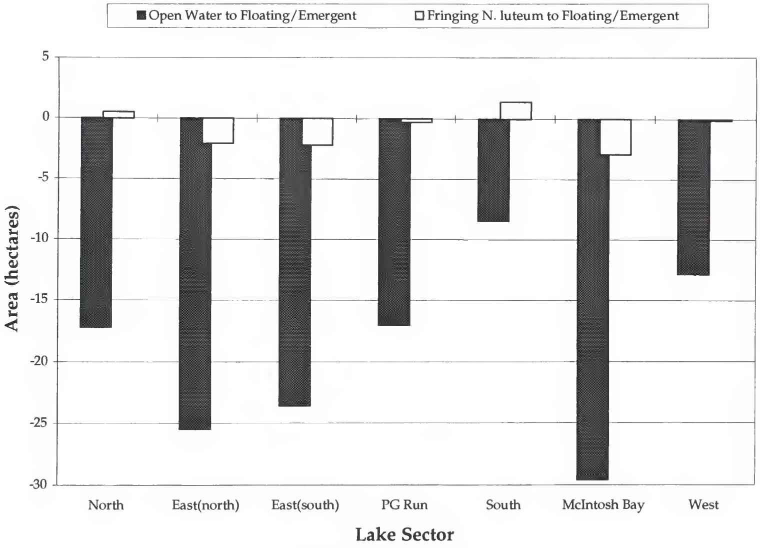


Figure 10. Sources of change in Floating/Emergent Wetland community area between January 22, 1994 and June 13, 1996. The value of Open Water to Floating/Emergent represents the net change in Open Water to Floating/Emergent area and Floating/Emergent to Open Water area. The value of Fringing *Nuphar luteum* to Floating/Emergent represents the net change in Fringing *Nuphar luteum* to Floating/Emergent area and Floating/Emergent to Fringing *Nuphar luteum* area.

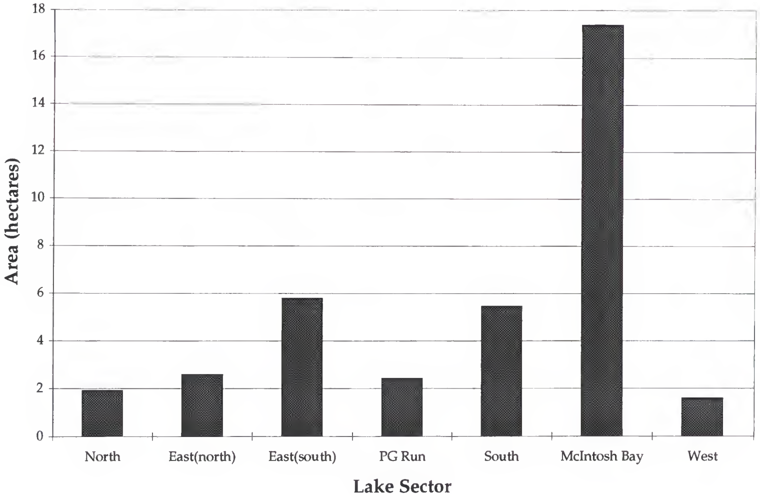


Figure 11. Lake sector Floating/Emergent Wetland community estimated to have translocated or formed between January 22, 1994 and June 13, 1996. These values represent the area of Floating/Emergent Wetland community which became established in areas previously identified as Open Water or Fringing *Nuphar luteum* communities.

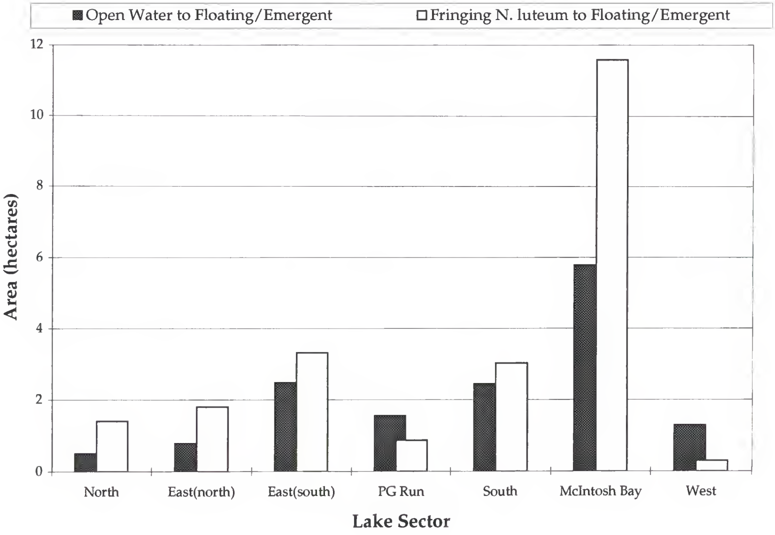


Figure 12. Sources of lake sector Floating/Emergent Wetland community formation and movement between January 22, 1994 and June 13, 1996. Values represent area of change from either Open Water or Fringing *Nuphar luteum* community into Floating/Emergent Wetland community area. This change could occur either by movement of floating islands or formation of a floating wetland.

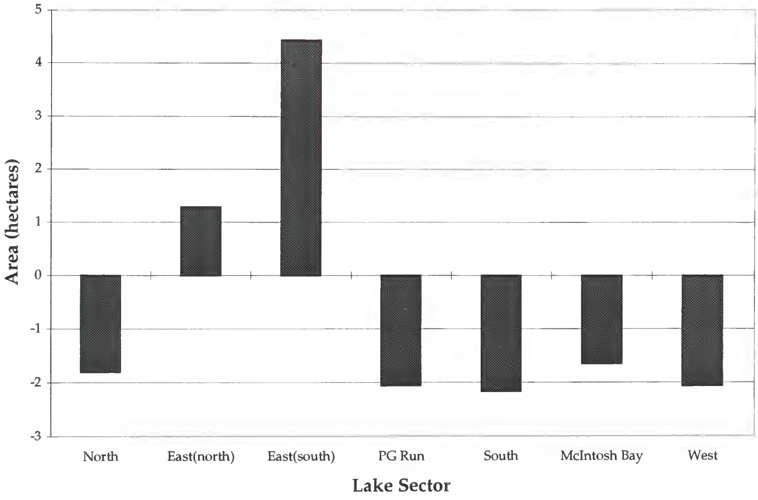


Figure 13. Change in Floating/Emergent Wetland community area in each lake sector between June 13, 1996 and July 23, 1996.

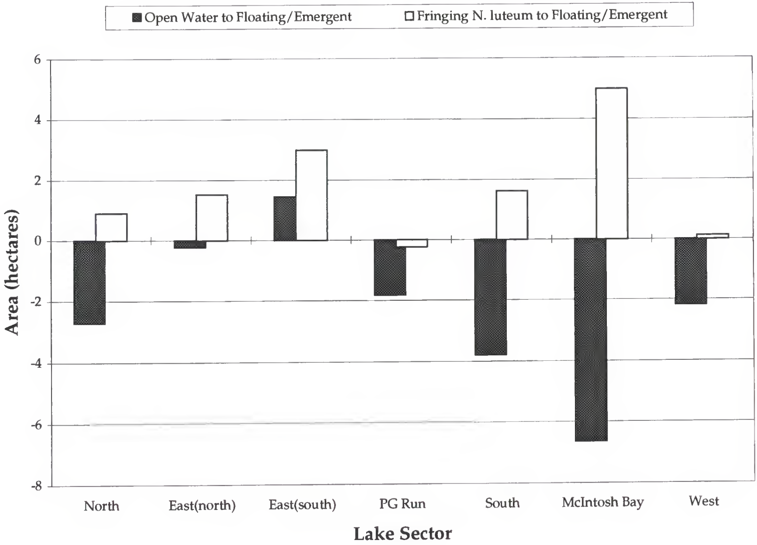


Figure 14. Sources of change in Floating/Emergent Wetland community area in each lake sector between June 13, 1996 and July 23, 1996. The value of Open Water to Floating/Emergent represents the net change in Open Water to Floating/Emergent area and Floating/Emergent to Open Water area. The value of Fringing *Nuphar luteum* to Floating/Emergent represents the net change in Fringing *Nuphar luteum* to Floating/Emergent area and Floating/Emergent to Fringing *Nuphar luteum* area.

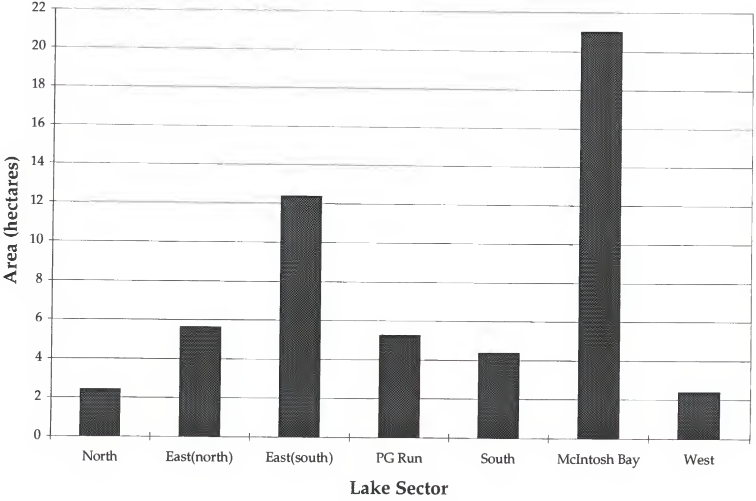


Figure 15. Lake sector Floating/Emergent Wetland community estimated to have translocated or formed between June 13, 1996 and July 23, 1996. These values represent the area of Floating/Emergent Wetland community which became established in areas previously identified as Open Water or Fringing *Nuphar luteum* communities.

Floating/Emergent Wetland community was most prominent in the East(south) Sector and McIntosh Bay Sector of the lake with areas of 12.4 and 11.0 ha, respectively. Areas with the least amount of movement and/or formation were the West Sector and the North Sector, which had 2.4 and 2.4 ha of change, respectively (Figure 15). Replacement of Open Water areas by Floating Wetland communities accounted for the majority of the formation and/or movement (Figure 16). The exception to this was in the North Sector and the McIntosh Bay Sector where movement and/or formation in fringing Deep Marsh Community areas accounted for a larger amount of change than that of Open Water community areas.

Change in Floating/Emergent Wetland Community Area between July 23, 1996 and September 24, 1996.

Change in Floating/Emergent Wetland community area had a lake wide net decrease of 4.4 ha between July 23, 1996 and September 24, 1996. This decline in coverage however, was not uniform throughout all lake sectors with the North, East(north) and PG Run sectors having net increases in Floating/Emergent Wetland community area, and the East(south), the South, the McIntosh Bay and the West Sectors having a net decrease in Floating/Emergent Wetland community area (Figure 17). Sources of change in the area of Floating/Emergent Wetland community coverage was a decline of 9.9 ha by change to Open Water and an increase of 5.5 ha by a change of fringing Deep Marsh habitat to Floating/Emergent Wetland community (Figure 6). Lake sectors North, East(north) and PG run had increases in Floating/Emergent Wetland community area by changing from Open Water. The East(south) and McIntosh Bay Sectors had declines in Floating/Emergent Wetland community area by change to Open

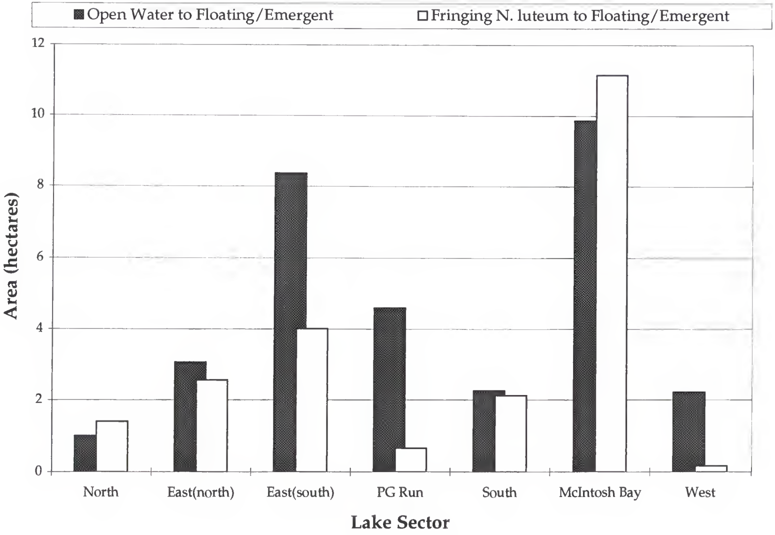


Figure 16. Sources of lake sector Floating/Emergent Wetland community formation and movement between June 13, 1996 and July 23, 1996. Values represent area of change from either Open Water or Fringing *Nuphar luteum* community into Floating/Emergent Wetland community area. This change could occur either by movement of floating islands or formation of a floating wetland.

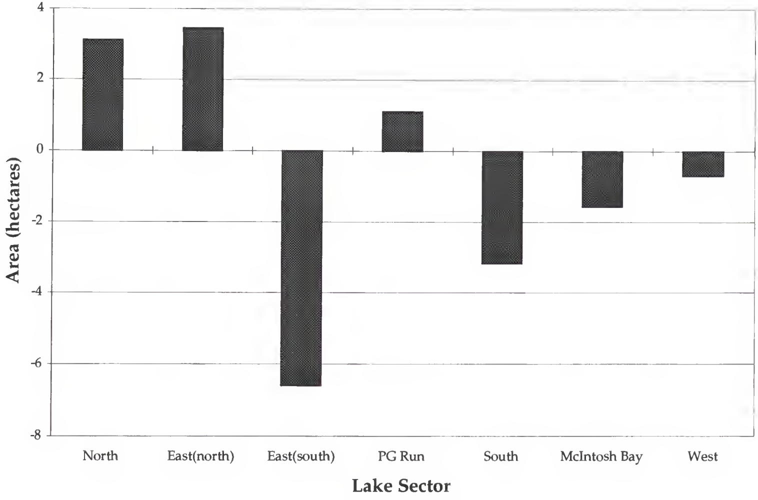


Figure 17. Change in Floating/Emergent Wetland community area in each lake sector between July 23, 1996 and September 24, 1996.

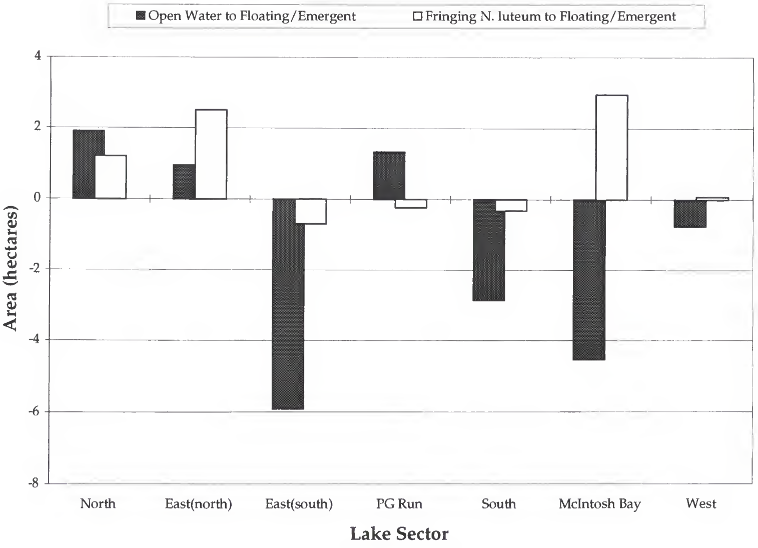


Figure 18. Sources of change in Floating/Emergent Wetland community area for each lake sector between July 23, 1996 and September 24, 1996. The value of Open Water to Floating/Emergent represents the net change in Open Water to Floating/Emergent area and Floating/Emergent to Open Water area. The value of Fringing *Nuphar luteum* to Floating/Emergent represents the net change in Fringing *Nuphar luteum* to Floating/Emergent area and Floating/Emergent to Fringing *Nuphar luteum* area.

Water community (-5.9 and -4.5 ha, respectively)(Figure 18). Changes in area involving fringing Deep Marsh community resulted in an increase in Floating/Emergent Wetland community area in the North, East(north) and McIntosh Bay sectors (1.2, 2.5 and 3.0 ha, respectively). Decreases in Floating/Emergent Wetland Community due to conversion to Fringing Deep Marsh community area occurred in the East(south),PG Run and South Sectors (-0.7, -0.2 and -0.3 ha, respectively).

Lake wide movement and formation of Floating/Emergent Wetland communities totaled 56.1 ha between July 23, 1996 and September 24, 1996. The greatest area of movement and/or formation was in the McIntosh Bay Sector (23.2 ha) and the smallest amount of activity noted was in the West Sector (2.1 ha)(Figure 19). In all seven sectors, movement and/or formation was primarily a change from Open Water community areas to Floating Wetland community (Figure 20). Change from fringing Deep Marsh community to Floating Wetland community was also noted. However, the McIntosh Bay Sector (8.4 ha), and East(north) Sector(3.0 ha) were the only lake sectors with greater than 1.5 ha of movement or formation occurring within an area previously designated as fringing Deep Marsh community.

Discussion

The survey of community cover between January 22, 1994 and September 24, 1996 indicated a significant decline in both Floating/Emergent Wetland community and fringing Deep Marsh community area. A decline in area of these communities corresponded to an equal increase in area of Open Water community. The mechanisms of change identified during this period were not directly studied, but appeared to be the

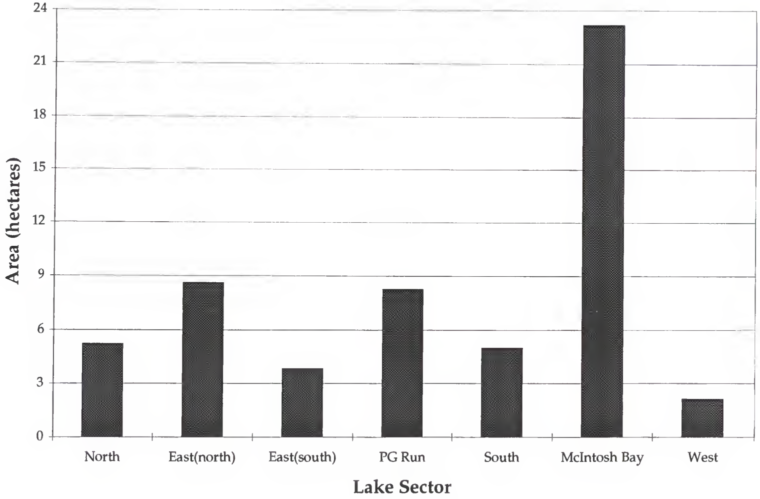


Figure 19. Lake sector Floating/Emergent Wetland community estimated to have translocated or formed between July 23, 1996 and September 24, 1996. These values represent the area of Floating/Emergent Wetland community which became established in areas previously identified as Open Water or Fringing *Nuphar luteum* communities.

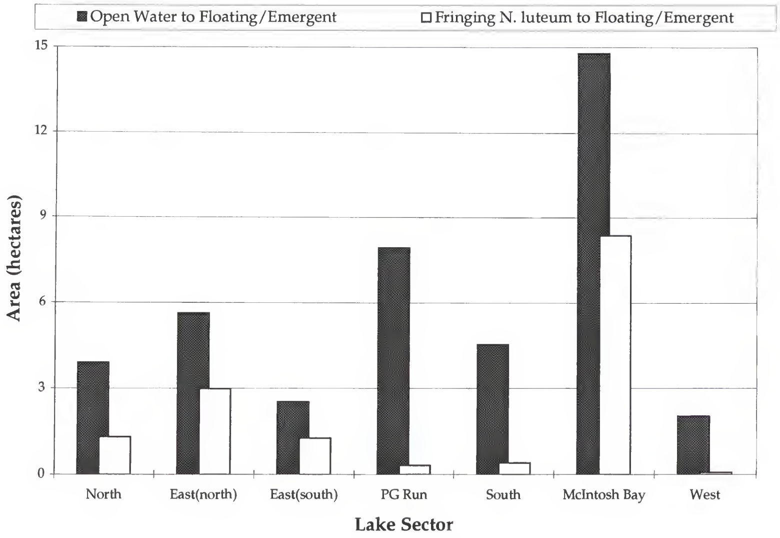


Figure 20. Sources of lake sector Floating/Emergent Wetland community formation and movement between July 23, 1996 and September 24, 1996. Values represent area of change from either Open Water or Fringing *Nuphar luteum* community into Floating/Emergent Wetland community area. This change could occur either by movement of floating islands or formation of a floating wetland.

result of both natural and anthropogenic processes. The decline in Floating/Emergent Wetland community and the decline in fringing Deep Marsh will be discussed in more detail.

The reduction in Floating/Emergent Wetland community area during this survey (149 ha) appears primarily to be a decline in that portion of this community that was floating. The largest decline in this community occurred between January 22, 1994 and June 13, 1996 (140 ha). During this period, water level increased from 55.47 ft NGVD to 57.85 ft NGVD (2.4 ft). There is some question whether or not a portion of the decline in Floating/Emergent Wetland community area was in part a reduction in emergent marsh area due to its inundation, rather than due to movement and/or subsidence of floating wetland. No specific evidence collected in this study can definitively answer this question. However, comparison of the location in which declines in this community occurred, using vegetative community maps of Orange Lake (Bryan, 1998; Robison et al., 1997), and a bathymeteric survey of Orange Lake (Danek et al., 1997), indicate that these areas were primarily composed of flotant communities and occurred in water depths greater than 0.75 m, the difference in water depth between the two sample periods. This supporting evidence leads us to believe that the change in Floating/Emergent Wetland community area is principally due to the loss of Flotant communities and not Emergent Wetland communities.

The mechanisms that resulted in the decline of Floating/Emergent Wetland community area are not specifically known, and therefore only probable mechanisms are presented here. One probable mechanism of the decline in flotant community is related to the increase in water level during the period of this communities greatest decline. The increase in water level between January 22, 1994 and June 13, 1996 likely reduced connectivity of the flotant with bottom sediments or may have created additional flotant community area from previously connected emergent marsh. Flotant created from previously connected marsh flotant emergent marsh or existing marsh flotant are then more likely to break loose when influenced by wind and currents. Once the marsh flotant began to break up, forming island flotant, they are likely to move into open water areas of the lake. Once in open water, physical disturbances such as wave action and hydraulic friction caused by islands moving through the water; and collisions with other islands, the shore, and bottom likely removed sediments from the underside of floating island communities. In the case of organic islands flotant, (Gleason et al., 1980) a significant decrease in the organic matrix available for the entrapment of gases could cause the islands to loose positive buoyancy and sink. In the case of vegetative island flotant, compaction and buckling of the island as a result of collisions with the shoreline and other islands could decrease aerial extent of the islands. Observations during this study identified several areas of island flotant that subsided in open water, became lodged below, or were suspended on top of other islands flotant. In other areas, vegetative marsh flotant and *Scirpus* vegetative marsh flotant, adjacent to open water areas, were often seen buckled and horizontally compressed, especially during strong wind events. These observations provide some support to the theory that movement and collision of floating wetlands, resulting from water level increases, may have influenced the decline in aerial extent of this community during this survey. It should be emphasized however, that water level, although the most plausible cause (based on the data available), may not be the only mechanism influencing the decline in flotant communities.

Physical harvesting and disturbance, herbicide application and burning of flotant have all been methods used in an effort to reduce the aerial extent of flotant on Orange

Lake. Although these efforts have resulted in varying degrees of effectiveness and have occurred on a small scale when compared to the total decline in Floating/Emergent Wetland community, control efforts made during this survey period likely contributed to some of the change. It was also noted during interpretation of the aerial photographs that the landward extent of change from flotant community to open water area was on occasion transected by an airboat trail. This finding might indicate that disturbance created by repeated airboat traffic reduced shoreline connectivity of the marsh flotant sufficiently to cause the lakeward portion of the community to break loose under higher water levels. Another anthropogenic effect on flotant communities appears to be the application of Fluridone during the late spring and summer of 1996.

Initially unintended to affect flotant communities, control efforts of *Hydrilla verticillata* appear to have influenced island flotant community movement, formation, and possibly subsidence. Due to positive buoyancy potential in deep marsh communities, a reduction in connectivity of *N. luteum* anchor roots to mineral sediments would likely cause this community to form island flotant if root connectivity to mineral sediments is was compromised (chapter 5). Although the direct effect of Fluridone application on the integrity of *N. luteum* roots has not been studied, degradation of foliage was noted during May, June and July of 1996. This loss of leaf matter, which is the plant's mechanism of gas transfer, may indirectly influence roots by reducing oxygen concentrations in the below ground tissue. During the period of largest decline in fringing Deep Marsh community (June 13, 1996 to July 23, 1996) net changes in fringing Deep Marsh community area to Floating/Emergent Wetland community area were 11.87 ha lake wide. The greatest decline of fringing Deep Marsh community during this period (4.98 ha) occurred in McIntosh Bay.

This increase of Floating/Emergent Wetland community from Deep Marsh community (11.87 ha, which occurred over a 2 month period) was greater than that calculated lake wide between January 22, 1994 and June 13, 1996 (5.6 ha of Floating/Emergent Wetland community became Deep Marsh Community) and that which occurred between July 23, 1996 and September 24, 1996 (5.5 ha of Deep Marsh community became Floating/Emergent Wetland community). Because the aerial survey does not discriminate between flotant that form from fringing Deep Marsh community and flotant that moved into an area previously occupied by a fringing Deep Marsh, it is difficult to state that all floating wetlands during this period formed from Deep Marsh community area. However, the relationship between the loss of fringing Deep Marsh habitat and increased flotant community area suggests that a large portion of flotant that formed during this period was the result of fringing Deep Marsh community that was affected by Fluridone. Although the Fluridone treatment may have resulted in an increase in the formation of island flotant, detection of this change was likely offset by an increase in mobility of existing floating wetland communities. The decline in fringing Deep Marsh community would have resulted in an increase in disturbance and reduction in the entrapment of marsh and island flotant along the shoreline. Therefore, although findings would suggest that Floating/Wetland communities were formed from Deep Marsh community during this period, increased mobility and hypothesized increased loss of island flotant when exposed to open water areas of the lake confounded the ability to calculate this change.

Fringing Deep Marsh community often appeared to entangle island flotant within *N. luteum* patches. This restricted flotant islands landward of the *N. Luteum* beds and inhibited them from entering open water areas. Prior to the decline in fringing Deep

Marsh area, it is likely that this Deep Marsh community barrier restricted movement of island flotant. It was estimated that between January 22, 1994 and June 13, 1996, 37.08 ha of floating wetlands moved and/or formed. During the survey periods in 1996, this number increased to 53.3 and 56.2 ha (June 13 to July 23. and July 23 to September 24, respectively). This increase in floating wetland mobility and/or formation, as it coincides with the decline in fringing Deep Marsh community was visually noted in the September 24, 1996 survey. During this period, areas of greatest Deep Marsh loss often also had an increased decline in adjacent marsh flotant area or in McIntosh Bay showed an increase in numbers of island flotant communities. One would expect, based on the proposed hypothesis, that this increase in movement of flotant to result in an overall decline in flotant community area. However, during the two survey periods that movement increased, lake wide area of Floating/Emergent Wetland community remained essentially constant, with 4.0 and 4.4 ha of loss. This apparent non-relationship between island flotant movement and losses may have been offset by equal amounts of loss and formation, or because the time frame in which degradation and loss of island flotant as a result of increased exposure in open water is longer than the duration of this survey.

It is possible that increased physical stresses on flotant integrity once exposed to the disturbance of open water areas may take a longer period of time to influence island buoyancy than the three months in which an increase in island mobility was noted. It is also possible that much of the long term subsidence of floating wetlands occurs during winter and therefore was not noted during the survey. As indicated in chapter 5, buoyancy of organic island flotant is primarily dependent upon sediment gases for positive buoyancy and is positively correlated with temperature. Physical disturbance influencing Orange Lake, such as wind and rain events, also differs between summer and winter months. For these reasons, subsidence and decline in flotant community area may be more common and frequent during the months of the year when water and sediment temperature are cooler and less likely to be offset by increased formation during warmer conditions. It is difficult to differentiate the effects of water level from the influence of colder weather periods on differences found between the January 22, 1994 to June 13, 1996 and June 13 to September 24, 1996 survey data. However, without further investigation, it is probable that all of these mechanisms influenced the flotant communities on Orange Lake and contributed to the differences found in this study.

Conclusions

As part of our initial objectives it is estimated that a maximum of 55 hectares of flotant between June 13 and July 23, 1996 were mobile in Orange Lake and 57 ha were mobile between July 23 and September 24, 1996. These estimates are a maximum because a distinction between mobile flotant and newly formed marsh flotant that is not mobile can not be made. These values are not likely to represent the average area of mobile flotant on the lake. Instead these numbers are probably greater than the average condition. The reason to expect these values may be larger is due to the hypothesized effects Fluridone may have on island mobility and formation.

The most active areas of island movement and or formation appear to be in the East(south) and McIntosh Bay Sectors. These areas had the greatest changes in aerial coverage of Floating/Emergent Wetland and Open Water cover types between survey periods. Selecting a sector that appears to be a sink or repository for island flotant was not possible. Change of Floating/Emergent Wetland area between survey sectors was too large and random to detect any pattern over this time period and frequency of sampling.

A general decline in Floating/Emergent Wetland cover, with subsequent increase in Open Water community area occurred between January 1994 and September 1996. Water level fluctuation, and increased mobility of island flotant followed by increased subsidence, may have been factors in this decline. This trend is opposite of that presumed to be occurring in the lake especially since the 1990-1991 drought. These conflicting directions of flotant cover may indicate a longer term cycling of community cover in the lake where island flotant formation, sinking, and redistribution of sediments and vegetation within the lake system follow periods of marsh flotant expansion. It may be possible to evaluate aerial photographs that date back to 1937 (in proximally 10 year increments) to determine whether a longer term cycle and infilling of the lake due to flotant formation has occurred.

CHAPTER 8
SUMMARY AND CONCLUSIONS

Flotant communities, defined as a floating mat of wetland macrophytes or a complex of macrophytes rooted in floating sediment, are unique among wetlands and aquatic systems with respect to short-term autochanous control of hydropattern and mobility of island forms of this community. Although there may be disagreement whether flotant should be considered "wetlands" or "floating aquatics", trying to establish a definitive characteristic between wetland and aquatic flotant would be difficult in the continuum of sediment and vegetative characteristics that these communities express, and even more difficult in trying to differentiate based on functional criteria. Regardless of how flotant might be classified within anthropocentrically defined environmental boundaries, the influence flotant communities have on vegetative composition, sediment relocation, and utilization of wetland and aquatic ecosystems can be significant.

As identified in Chapter 1, Orange Lake in north central Florida, has a documented history of flotant, extending to the mid 1800s. In 1996 and 1997 a study of these communities was conducted to address several biophysical and mechanistic characteristics of flotant communities in Orange Lake. Five specific objectives were addressed in studies described in chapter 2, and chapters 4 through 7. A summary of experimental results addressing each of the stated objectives is presented below.

Determine the effect flotant may have on vegetative composition of Orange Lake.

Flotant communities, especially those with organic sediment, has significantly increased species richness of the Orange Lake ecosystem. It was found that 23 of 59 species identified occurred exclusively on flotant, with eight of these species found only on organic flotant. Vegetative flotant forming species *Hydrocotyle umbellata* and *Limnobium spongia* were the most frequently identified species in the eleven communities sampled. *Limnobium spongia* had the highest species importance value as determined by frequency of occurrence and percent cover among all species. Organic marsh flotant communities had the highest vegetative species richness of any community surveyed, averaging 17 species per two-square-meter area. This community also had the highest species richness at any single sample location (22 species 2 m^{-2}), and the greatest species richness of any community surveyed (34 species). These findings suggest that the presence of flotant in Orange Lake either provides vegetative habitat otherwise not available in non-floating communities, or that it is exploiting habitat where it has a greater competitive advantage than that of emergent wetland species.

Characterize and classify below-water vertical profile of flotant communities.

Sediment surface of organic island flotant or organic marsh flotant ranged between 6 cm above the water surface to 17 cm below the water surface. Several of the sites within these communities also had microtopographic relief of up to 10 cm. Thickness of organic sediments on organic island flotant averaged 61 cm thick, and in organic marsh flotant averaged 30 cm thick. Vegetative flotant communities were characterized by a zone of intertwined stems, roots and stolons averaging 18 cm thick and a lower zone of vertical roots suspended in the water column that averaged 40 cm thick.

At sampling sites of sufficiently shallow water, tips of roots found in the vertical root zone, especially those of *Limnobium spongia*, often penetrated bottom sediments. Vegetative island flotant or vegetative marsh flotant does not appear to accumulate organic sediment. Vegetative marsh flotant had greater amounts of litter and recalcitrant vegetation than vegetative island flotant. General classification between organic flotant and vegetative flotant, between island flotant and marsh flotant, and identification of dominant species are relatively simple and provide a good system for classification. However, within these categories a continuum of biophysical characteristics exists and distinction between types of flotant within these categories will require another as yet undefined parameter for classification.

Determine what components of flotant provide buoyancy and contrast these with non-flotant wetland and open water communities in an attempt to understand flotant formation mechanisms.

Quantification of buoyancy components and calculation of buoyancy budgets indicate vegetative flotant has little or no positive buoyancy resulting from gases trapped externally in the root matrix. Positive buoyancy at these sites is almost exclusively from vegetative components. Organic flotant communities are principally dependent upon gases trapped within the organic sediments to maintain positive net buoyancy. Most non-floating emergent wetland sites had positive net buoyancy values indicating some component(s) of negative buoyancy were not accounted for in this study. Connectivity to mineral components below the organic/mineral sediment interface may account for this discrepancy and may be a significant factor in regulating flotant formation. Although components of flotant that provide the principal components of positive buoyancy have been identified, dynamic mechanisms of how these components increase or decrease to trigger flotant formation cannot be definitively determined at this time.

Determine whether there is evidence of flotant formation within the lake sediments, and if this evidence is found can it be used to infer the role of flotant on successional development of the lake.

Peat stratigraphy of cores collected in Orange Lake provide considerable evidence of historic flotant formation. Reversal in ^{14}C chronology and specific assemblages of plant fragments indicative of present day flotant, were used to provide evidence within buried horizons. Although not conclusive, plausible evidence suggests that translocation of sediments by flotant or suitable germination conditions provided by flotant, act as nuclei to scrub-swamp community development similar to that identified in the Okefenokee Swamp and Northeastern Everglades. Horizontal expansion of marsh flotant into open water, fragmentation of marsh flotant to island flotant and translocation and sinking of sediment by island flotant may be a significant component in the hydrarch succession of Orange Lake.

Quantify spatial and temporal change of flotant communities within the open water areas of the lake.

A general decline in Floating/Emergent Wetland cover, with subsequent increase in Open Water community area occurred between January 1994 and September 1996. A maximum of 55 hectares of flotant between June 13 and July 23, 1996 were mobile in Orange Lake, and 57 ha were mobile between July 23 and September 24, 1996. These estimates are a maximum because a distinction between mobile flotant and newly formed marsh flotant that is not mobile cannot be made. The most active areas of island movement and or formation appear to be in the East (south) and McIntosh Bay Sectors. These areas had the greatest changes in aerial coverage of Floating/Emergent Wetland and Open Water cover types between survey periods. Island flotant formation resulting from marsh flotant fragmentation was identified at several locations.

Ecological and Environmental Significance

Structural and functional characteristics of an ecosystem, and its subset of communities, are the result of countless interactions and environmental forcing functions. Over time forcing functions are likely to change, as well as many of the countless interactions, resulting in subsequent change in structure and function of some or all of the communities. Regardless of the changes that occur, resources that become available will be exploited causing new species to thrive, while other resources that become limited will cause other species to decline. There is no “good” community or “bad” community only the species, populations, communities and ecosystems that are most efficient at optimizing the resources available.

Flotant communities are some of the community types that have optimized the conditions presently occurring in Orange Lake. Whether occurrence is suggestive of a stage in hydrarch succession, or random conditions that are not specific to an aquatic ecosystems chronological sequence is not known. It is apparent, however, that conditions in Orange Lake have been favorable to flotant formation for several hundred years and during that period has influenced landscape scale features of the lake, wildlife habitat, and has a significant effect on present day vegetative composition of the lake ecosystem. Unfortunately, some characteristics of flotant have led to a conflict between the goals that some ecosystem managers have for the lake and the structural and functional communities that lake conditions are presently promoting. Efforts have been made to try and "restore" some areas of the lake by harvesting flotant, but these efforts come at great expense, have difficulty addressing islands that are the most problematic type of flotant to navigation and access, and are relatively short lived, as the ecosystem is prone to continue to form more flotant communities.

Findings from this study that may be useful to managers addressing issues of flotant formation include the following. Components regulating buoyancy on organic flotant differs from that of vegetative flotant, therefore, conditions that cause the formation of organic flotant likely differ from conditions that cause the development of vegetative flotant. In the case of organic flotant, accumulation of sediment gases within the organic matrix, and connectivity of roots and organic sediment to underlying mineral sediment, was the predominant components/factors regulating buoyancy. Natural conditions or management decisions that result in increased sediment gas accumulation, or compromise connectivity of roots and sediments, may result in increased flotant formation. Conversely, if management objectives are to reduce flotant formation, system wide treatment attempts would be optimized if targeted at increasing connectivity of vegetation with underlying mineral sediments and to reduce conditions that promote an accumulation of sediment gases.

Environmental conditions promoting vegetative flotant or management efforts to control it may differ from those that influence organic flotant formation. Vegetative flotant buoyancy was regulated only by the displacement volume of below-water biomass relative to the overall mass of the vegetation. Therefore management of environmental conditions that influence growth and establishment of species prone to vegetative flotant formation would be the optimal way to regulate the formation and expansion of these communities.

Whether the objective is management or increased understanding of the processes that regulate successional patterns of flotant formation within a lake, formation of flotant in simplistic terms is the result of a change in net buoyancy conditions from net negative to net positive. However, the biogeochemical and physical processes that regulate components of buoyancy, and the interaction between components of buoyancy to actuate change from net negative to net positive is complex. Further investigations of dynamic change that occur in buoyancy components under varying environmental conditions, and species specific influences on components of buoyancy and connectivity with mineral sediments are required before a more mechanistic answer to the formation of flotant can be provided.

APPENDIX A

SPECIES COMMUNITY ASSOCIATIONS
AND
SPECIES COMPOSITION OF SITES SURVEYED

Table A-1. Organic Island Flotant (Fla). Species composition and cover, species analysis, and site and community analysis.

	Species Composition and Cover														**Species Analysis**	
	Zone 1, 1996 Fla-1A		Zone 1, 1997 Fla-1B		Zone 2, 1996 Fla-2A		Zone 2, 1996 Fla-2B		Zone 2, 1997 Fla-2C		Zone 3, 1996 Fla-3A		Zone 3, 1997 Fla-3B		Average Cover (2 m^2)	Importance Value*
Species	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead		
Alternanthera philoxeroides	1	0	0		0		0		0		0		0		0.143	0.104
Amaranthus australis			1		3	0									0.571	0.133
Andropogon virginicus							0		1						0.143	0.050
Bidens laevis			1	0	3		3		1		3		0		1.571	0.371
Bidens mitis									0						0.000	0.011
Boehmeria cylindrica													0		0.000	0.011
Cicuta mexicana									0						0.000	0.011
Cyperus odorata			0		0		1	0							0.143	0.060
Eichhornia crassipes					0										0.000	0.011
Eleocharis baldwinii	0	0	0		0		0		0				0		0.000	0.065
Eupatorium capillifolium			3	0	0		0		0		1				0.571	0.165
Habenaria repens			0		0				0		0		0		0.000	0.054
Hydrocotyle ranunculoides			0		0				0						0.000	0.033
Hydrocotyle umbellata	1	0	1	0	1		0		0		2		0		0.714	0.215
Juncus effusus									0						0.000	0.011
Lemna sp.									0						0.000	0.011
Limnobium spongia							0	0	0				0		0.000	0.033
Ludwigia leptocarpa	0	0	0		1						3	1			0.714	0.182
Mikania scandens							0						0		0.000	0.022
Nuphar luteum	1	0	0		0		0		0		0		2	0	0.143	0.104
Panicum hemitomon			0				1		0						0.143	0.060
Pistia stratiotes							0								0.000	0.011
Pluchea purpurascens			0												0.000	0.011
Polygonum densiflorum			0	0			0						0	0	0.000	0.033
Pontederia cordata	1	0			0		1	0	0	0					0.286	0.099
Sagittaria latifolia			0						0						0.000	0.022
Scirpus cubensis									0						0.000	0.011
Solidago fistulosa							0		0						0.000	0.022
Typha latifolia	0	0			0				0				0	0	0.000	0.043
Unk Gramineae seedling 1	0	0			0										0.000	0.022
Unk Gramineae seedling 2	0	0													0.000	0.011

* Determined by summing the values of relative frequency and relative coverage for species.

Cover class code, 0 (1-9%), 1 (10-19%), 2 (20-29%), 3 (30-39%), 4 (40-49%), 5 (50-59%), 6 (60-69%), 7 (70-79%), 8 (80-89%), 9 (90-99%)

Table A-1 cont.

Site and Community Analysis

	Fla-1A	Fla-1B	Fla-2A	Fla-2B	Fla-2C	Fla-3A	Fla-3B
Site species richness (2 m^2)	9	15	15	15	20	7	11
Average site species richness	13.1						
Community species richness	31						
Simpson's Diversity Index	0.87	0.89	0.87	0.89	0.95	0.79	0.86
	0.92		0.93			0.87	

Morisita's index of community similarity

Lake Zone I \ Lake Zone II	0.590
Lake Zone I \ Lake Zone III	0.740
Lake Zone II \ Lake Zone III	0.613

Table A-2. Vegetative Island Flotant (FIb). Species composition and cover, species analysis, and site and community analysis.

Species Composition and Cover
Site

Species Analysis

	Zone 1, 1996 FIb-1A		Zone 1, 1997 FIb-1B		Zone 2, 1996 FIb-2A		Zone 2, 1997 FIb-2B		Zone 3, 1996 FIb-3A		Zone 3, 1997 FIb-3B			
Species	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Cover (2 m^2)	Importance Value*
Alternanthera philoxeroides					0		0		0				0.000	0.067
Bidens laevis	0								0				0.000	0.044
Cicuta mexicana			0								0		0.000	0.044
Eichhornia crassipes							0		0				0.000	0.044
Habenaria repens	0										0		0.000	0.044
Hydrocotyle umbellata	4		0				0		0		1	0	0.833	0.233
Lemna sp.	0				0								0.000	0.044
Limnobium spongia	1		9	0	9	0			1	0	1	0	3.500	0.623
Mikania scandens	0												0.000	0.022
Nuphar luteum							0						0.000	0.022
Panicum hemitomon			0	0									0.000	0.022
Polygonum densiflorum	0	0	0	0	0		5		0	0	0	0	0.833	0.255
Pontederia cordata	0												0.000	0.022
Salvinia minima											0		0.000	0.022
Scirpus cubensis	0	1	0	0	0	0			5	1	3	0	1.333	0.306
Spirodela polyrhiza	0		0										0.000	0.044
Typha latifolia	0	0	0	0		0							0.000	0.044
Utricularia fibrosa			0	0							2		0.333	0.093

* Determined by summing the values of relative frequency and relative coverage for species.

Cover class code, 0 (1-9%), 1 (10-19%), 2 (20-29%), 3 (30-39%), 4 (40-49%), 5 (50-59%), 6 (60-69%), 7 (70-79%), 8 (80-89%), 9 (90-99%)

Site and Community Analysis

	FIb-1A	FIb-1B	FIb-2A	FIb-2B	FIb-3A	FIb-3B
Site species richness (2 m^2)	11	9	6	5	7	8
Average site species richness	7.7					
Community species richness	18					
Simpson's Diversity Index	0.79	0.50	0.32	0.46	0.64	0.81
	0.74		0.65		0.76	

Morisita's index of community similarity

Lake Zone I \ Lake Zone II	0.817
Lake Zone I \ Lake Zone III	0.448
Lake Zone II \ Lake Zone III	0.354

Table A-3. Vegetative Marsh Flotant (FMb). Species composition and cover, species analysis, and site and community analysis.

	Species Composition and Cover												Species Analysis	
	Site													
	Zone 1, 1996 FMb-1A		Zone 1, 1997 FMb-1B		Zone 2, 1996 FMb-2A		Zone 2, 1997 FMb-2B		Zone 3, 1996 FMb-3A		Zone 3, 1997 FMb-3B		Average Cover (2 m^2)	Importance Value*
Species	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead		
Alternanthera philoxeroides			0										0.000	0.017
Azolla caroliniana							0						0.000	0.017
Bidens laevis	0		0										0.000	0.034
Cicuta mexicana	0		0		0	0							0.000	0.051
Cladium jamaicense											1	0	0.167	0.037
Cuscuta gronovii					0	0							0.000	0.017
Decodon verticillata	0		0		0	0					0	0	0.000	0.068
Galium tinctorium			0										0.000	0.017
Habenaria repens	0		0		0	0	0				0		0.000	0.085
Hydrocotyle ranunculoides							0						0.000	0.017
Hydrocotyle umbellata	0		0		1	0			0		0		0.167	0.105
Lemna sp.	0		0		0	0							0.000	0.051
Limnobium spongia	3	0	8	0	7	0	5	0	7	0	3	0	5.500	0.775
Nuphar luteum									1		1	0	0.333	0.075
Panicum hematomon	0						2	0	0				0.333	0.092
Peltandra virginica	2	0									3	0	0.833	0.136
Polygonum densiflorum	0	0			1	1	0	0					0.167	0.071
Polygonum hydropiperoides											0		0.000	0.017
Pontederia cordata							0						0.000	0.017
Sagittaria lancifolia											0	0	0.000	0.017
Salvinia minima	0						1		0		1		0.333	0.109
Scirpus cubensis			1	0	0	0	0	0					0.167	0.071
Spirodela polyrhiza	0		0		0	0	1		0				0.167	0.105
Unk Gramineae seedling 2	0												0.000	0.017
Wolfiella floridana	0												0.000	0.017

* Determined by summing the values of relative frequency and relative coverage for species.

Cover class code, 0 (1-9%), 1 (10-19%), 2 (20-29%), 3 (30-39%), 4 (40-49%), 5 (50-59%), 6 (60-69%), 7 (70-79%), 8 (80-89%), 9 (90-99%)

Table A-3 cont.

Site and Community Analysis

	FMb-1A	FMb-1B	FMb-2A	FMb-2B	FMb-3A	FMb-3B
Site species richness (2 m^2)	14	12	10	10	6	10
Average site species richness	10.3					
Community species richness	25					
Simpson's Diversity Index	0.86	0.64	0.69	0.79	0.52	0.84
	0.77		0.76		0.76	

Morisita's index of community similarity

Lake Zone I \ Lake Zone II	0.962
Lake Zone I \ Lake Zone III	0.941
Lake Zone II \ Lake Zone III	0.899

Table A-4. *Scirpus* Vegetative Marsh Flotant (FMa(S)). Species composition and cover, species analysis, and site and community analysis.

	Species Composition and Cover						Species Analysis	
	Site							
	Zone 1, 1997 FMa-1B		Zone 2, 1996 FMa-2A		Zone 3, 1997 FMa-3B		Average Cover (2 m^2)	Importance Value*
Species			Live	Dead				
Bidens laevis	0		0		0		0	0.167
Bidens mitis			0				0	0.056
Habenaria repens	0		0		0		0	0.167
Hydrocotyle umbellata	3	0	1		1	0	2	0.417
Limnobium spongia	0		1	0	1	0	1	0.267
Polygonum densiflorum			0	0			0	0.056
Salvinia minima			0	0			0	0.056
Scirpus cubensis	3	0	6	1	4	2	4	0.817

* Determined by summing the values of relative frequency and relative coverage for species.

Cover class code, 0 (1-9%), 1 (10-19%), 2 (20-29%), 3 (30-39%), 4 (40-49%), 5 (50-59%), 6 (60-69%), 7 (70-79%), 8 (80-89%), 9 (90-99%)

Site and Community Analysis

	FMa-1B	FMa-2A	FMa-3B
Site species richness (2 m^2)	5	8	5
Average site species richness	6.0		
Community species richness	8		
Simpson's Diversity Index	0.66	0.67	0.66

Morisita's index of community similarity
Dominated by Scirpus cubensis

Lake Zone I \ Lake Zone II	0.865
Lake Zone I \ Lake Zone III	0.912
Lake Zone II \ Lake Zone III	1.013

Table A-5. Organic Marsh Flotant (FMc). Species composition and cover, species analysis, and site and community analysis.

	Species Composition and Cover												**Species Analysis**	
	Site													
	Zone 1, 1996 FMc-1A		Zone 1, 1997 FMc-1B		Zone 2, 1996 FMc-2A		Zone 2, 1997 FMc-2B		Zone 3, 1996 FMc-3A		Zone 3, 1997 FMc-3B		Average Cover (2 m^2)	Importance Value*
Species	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead		
Acer rubrum											0		0.000	0.010
Alternanthera philoxeroides	0						0						0.000	0.020
Andropogon glomeratus											1	0	0.167	0.039
Azolla caroliniana			0						0				0.000	0.020
Bidens laevis	3	2	0		0		1		0		0		0.667	0.174
Bidens mitis			0		0				1	0	1		0.333	0.097
Boehmeria cylindrica	0		0						0		0		0.000	0.040
Cicuta mexicana	0	0	1	0	0	0			0				0.167	0.069
Decodon verticillata	2	0	1	0	1		0		1	0	1	0	1.000	0.231
Eleocharis baldwinii			0		0		1		0				0.167	0.069
Erianthus giganteus									1	0			0.167	0.039
Galium tinctorium			0						0				0.000	0.020
Habenaria repens	0		0	0	0		1	0	0				0.167	0.079
Hydrocotyle ranunculoides							0				0		0.000	0.020
Hydrocotyle umbellata	0	0	0		0	0			1		0		0.167	0.079
Lemna sp.	0				0		0				0		0.000	0.040
Limnobium spongia	2	0	1		1		3	1	1		0		1.333	0.289
Ludwigia leptocarpa			0							0			0.000	0.010
Mikania scandens	0		0		0						0	0	0.000	0.040
Panicum hemitomon			1	0	0	0	0	0					0.167	0.059
Polygonum densiflorum	0	0			0		0	0	0		0	0	0.000	0.050
Pontederia cordata			2	0	1	0			0				0.500	0.116
Sagittaria lancifolia	0				1	0							0.167	0.049
Sagittaria latifolia									0	0	0		0.000	0.020
Scirpus cubensis			0		0	0	1	0					0.167	0.059
Salvinia minima			0		0		0		0				0.000	0.040
Solidago fistulosa											0		0.000	0.010
Spirodela polyrhiza			0						0		0		0.000	0.030
Thelypteris thelypteroides					1	0			1	0	1	0	0.500	0.116
Triadenum virginicum									0	0			0.000	0.010
Typha latifolia	0	0				0			0	0			0.000	0.020
Unk Gramineae #3									0				0.000	0.010
Utricularia fistulosa			0				0						0.000	0.020
Wolffiella floridana			0				0						0.000	0.020

* Determined by summing the values of relative frequency and relative coverage for species.

Cover class code, 0 (1-9%), 1 (10-19%), 2 (20-29%), 3 (30-39%), 4 (40-49%), 5 (50-59%), 6 (60-69%), 7 (70-79%), 8 (80-89%), 9 (90-99%)

Table A-5 cont.

Site and Community Analysis

	FMc-1A	FMc-1B	FMc-2A	FMc-2B	FMc-3A	FMc-3B
Site species richness (2 m^2)	13	20	18	14	22	16
Average site species richness	17.2					
Community species richness	34					
Simpson's Diversity Index	0.86	0.93	0.93	0.89	0.94	0.92
	0.92		0.93		0.94	

Morisita's index of community similarity

Lake Zone I \ Lake Zone II	0.843
Lake Zone I \ Lake Zone III	0.622
Lake Zone II \ Lake Zone III	0.605

Table A-6. Deep Marsh Community (DMa). Species composition and cover, species analysis, and site and community analysis.

	Species Composition and Cover																Species Analysis	
	Site																	
	Zone 1, 1996 DMa-1A		Zone 1, 1996 DMa-1B		Zone 1, 1997 DMa-1C		Zone 2, 1996 DMa-2A		Zone 2, 1996 DMa-2B		Zone 2, 1997 DMa-2C		Zone 3, 1996 DMa-3A		Zone 3, 1997 DMa-3B		Average Cover (2 m^2)	Importance Value*
Species	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead		
Alternanthera philoxeroides	0		0		0	0											0	0.107
Azolla caroliniana													0	0	0		0	0.071
Hydrocotyle umbellata					0	0							0	0			0	0.071
Lemna sp.					0												0	0.036
Limnobium spongia					0								2	0	2	0	1	0.189
Nuphar luteum	1	0	7	0	8	0	5	0	3	0	6	0	1	0	1		4	0.939
Nymphaea odorata													5	0	6		1	0.296
Polygonum densiflorum													0	0			0	0.036
Pontederia cordata					0												0	0.036
Utricularia inflata							1										0	0.056
Utricularia macrorhiza			0						0				1	0	0		0	0.163

* Determined by summing the values of relative frequency and relative coverage for species.

Cover class code, 0 (1-9%), 1 (10-19%), 2 (20-29%), 3 (30-39%), 4 (40-49%), 5 (50-59%), 6 (60-69%), 7 (70-79%), 8 (80-89%), 9 (90-99%)

Site and Community Analysis

	DMa-1A	DMa-1B	DMa-1C	DMa-2A	DMa-2B	DMa-2C	DMa-3A	DMa-3B
Site species richness (2 m^2)	2	3	6	2	2	1	7	5
Average site species richness	3.5							
Community species richness	11							
Simpson's Diversity Index	0.42	0.23	0.40	0.35	0.24	0.02	0.74	0.62
		0.58			0.55		0.67	

Morisita's Index of community similarity	
Lake Zone I \ Lake Zone II	1.000
Lake Zone I \ Lake Zone III	0.747
Lake Zone II \ Lake Zone III	0.720

Table A-7. *Panicum* Marsh Community . Species composition and cover, species analysis, and site and community analysis.

	Species Composition and Cover Site						Species Analysis	
	Zone 1, 1996 FMa-1A		Zone 2, 1997 FMa-2B		Zone 3, 1996 FMa-3A		Average Cover (2 m^2)	Importance Value*
Species	Live	Dead	Live	Dead	Live	Dead		
Amaranthus australis			0				0	0.059
Galium tinctorium	0						0	0.059
Habenaria repens	0						0	0.059
Hydrocotyle ranunculoides			0		0	0	0	0.118
Lemna sp.	0						0	0.059
Limnobium spongia	0		0		0		0	0.176
Panicum hemitomon	8	1	8	1	7	2	8	1.176
Peltandra virginica					0		0	0.059
Polygonum densiflorum			0				0	0.059
Spirodela polyrhiza	0		0		0		0	0.176

* Determined by summing the values of relative frequency and relative coverage for species.

Cover class code, 0 (1-9%), 1 (10-19%), 2 (20-29%), 3 (30-39%), 4 (40-49%), 5 (50-59%), 6 (60-69%), 7 (70-79%), 8 (80-89%), 9 (90-99%)

Site and Community Analysis

	FMa-1A	FMa-2B	FMa-3A
Site species richness (2 m^2)	6	6	5
Average site species richness	5.7		
Community species richness	10		
Simpson's Diversity Index	0.40	0.40	0.38

Morisita's index of community similarity

Dominated by Panicum hemitomon

Lake Zone I \ Lake Zone II	1.005
Lake Zone I \ Lake Zone III	1.006
Lake Zone II \ Lake Zone III	1.010

Table A-8. Broad-leaf Shallow Marsh Community (SMa). Species composition and cover, species analysis, and site and community analysis.

Species Composition and Cover / **Species Analysis**

	Site													
	Zone 1, 1996 SMa-1A		Zone 1, 1997 SMa-1B		Zone 2, 1996 SMa-2A		Zone 2, 1997 SMa-2B		Zone 3, 1996 SMa-3A		Zone 3, 1997 SMa-3B		Cover	Importance Value*
Species	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	(2 m^2)	
Alternanthera philoxeroides	0	0											0.000	0.020
Azolla caroliniana	0												0.000	0.020
Boehmeria cylindrica			0										0.000	0.020
Cicuta mexicana			0	0			0	0	0	0			0.000	0.059
Decodon verticillata			1				0		0				0.167	0.082
Eleocharis baldwinii											0		0.000	0.020
Habenaria repens	0	0			0	0					1	0	0.167	0.082
Hydrocotyle umbellata			0				0	0	1	0	0		0.167	0.101
Lemna sp									0				0.000	0.020
Limnobium spongia	2	0			6	0	3	0	1	0	4	1	2.667	0.462
Nuphar luteum							1						0.167	0.042
Panicum hematomon	1	0	1	0	1	0	0	0					0.500	0.147
Peltandra virginica			0	0			2	0	2	0			0.667	0.150
Polygonum densiflorum	0	0											0.000	0.020
Polygonum hydropeperoides			0										0.000	0.020
Pontederia cordata	5	0			2	0					2	1	1.500	0.263
Sacciolepis striata	0	0											0.000	0.020
Sagittaria lancifolia			2	0			3	0	2	1			1.167	0.218
Salix caroliniana				0									0.000	0.000
Salvinia minima					0	0	0		0		1		0.167	0.101
Spirodela polyrhiza							0		0				0.000	0.039
Typha latifolia			0									0	0.000	0.020
Unk. Gramineae seedling #1	0												0.000	0.020
Utricularia fibrosa											0		0.000	0.020
Wolffiella floridana							0		0				0.000	0.039

* Determined by summing the values of relative frequency and relative coverage for species.

Cover class code, 0 (1-9%), 1 (10-19%), 2 (20-29%), 3 (30-39%), 4 (40-49%), 5 (50-59%), 6 (60-69%), 7 (70-79%), 8 (80-89%), 9 (90-99%)

Site and Community Analysis

	SMa-1A	SMa-1B	SMa-2A	SMa-2B	SMa-3A	SMa-3B
Site species richness (2 m^2)	9	10	5	11	10	8
Average site species richness	8.8					
Community species richness	25					
Simpson's Diversity Index	0.75	0.84	0.62	0.84	0.86	0.77
	0.88		0.81		0.87	

Morisita's index of community similarity

Lake Zone I \ Lake Zone II	0.648
Lake Zone I \ Lake Zone III	0.655
Lake Zone II \ Lake Zone III	0.916

Table A-9. Linear-leaf Shallow Marsh Community (SMb). Species composition and cover, species analysis, and site and community analysis.

	Species Composition and Cover												Species Analysis	
	Site													
	Zone 1, 1996 SMb-1A		Zone 1, 1997 SMb-1B		Zone 2, 1996 SMb-2A		Zone 2, 1997 SMb-2B		Zone 3, 1996 SMb-3A		Zone 3, 1997 SMb-3B			
Species	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Cover (2 m^2)	Importance Value*
Alternanthera philoxeroides					0								0.000	0.026
Azolla caroliniana	0	0											0.000	0.026
Boehmeria cylindrica											0		0.000	0.026
Scirpus cubensis					0				0	0			0.000	0.051
Cladium jamaicense	4	3	3	2					5	2	4	2	2.667	0.636
Decodon verticillata			0		1	0			0		0		0.167	0.136
Hydrocotyle ranunculoides							0						0.000	0.026
Hydrocotyle umbellata									0		0		0.000	0.051
Lemna sp.	0	0											0.000	0.026
Limnobium spongia	1	0			0		0		1	0	0		0.333	0.195
Nuphar luteum			0				3	0					0.500	0.151
Nymphaea odorata									0				0.000	0.026
Peltandra virginica											0	0	0.000	0.026
Polygonum hydropiperoides			0										0.000	0.026
Sagittaria lancifolia	1	0	1	0					0	0			0.333	0.144
Salvinia minima	0	0							0		0		0.000	0.077
Scirpus californicus							3	1					0.500	0.126
Spirodela polyrhiza					0								0.000	0.026
Thelypteris thelypteroides			0		0								0.000	0.051
Typha latifolia					3	3							0.500	0.126
Wolfiella floridana							0						0.000	0.026

* Determined by summing the values of relative frequency and relative coverage for species.

Cover class code, 0 (1-9%), 1 (10-19%), 2 (20-29%), 3 (30-39%), 4 (40-49%), 5 (50-59%), 6 (60-69%), 7 (70-79%), 8 (80-89%), 9 (90-99%)

Site and Community Analysis

	SMb-1A		SMb-1B	SMb-2A		SMb-2B	SMb-3A		SMb-3B
Site species richness (2 m^2)	6		6	7		5	8		7
Average site species richness	6.5								
Community species richness	21								
Simpson's Diversity Index	0.70		0.70	0.73		0.66	0.67		0.63
		0.71			0.84			0.65	

Morisita's index of community similarity

Lake Zone I \ Lake Zone II	0.074
Lake Zone I \ Lake Zone III	0.951
Lake Zone II \ Lake Zone III	0.053

Table A-10. Scrub-Shrub Swamp Community (SSa). Species composition and cover, species analysis, and site and community analysis.

	Species Composition and Cover												Species Analysis	
	Site													
	SSa-1A		SSa-1B		SSa-2A		SSa-2B		SSa-3A		SSa-3B			Importance
Species	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Cover (2 m^2)	Value*
Boehmeria cylindrica			0								0		0.000	0.035
Cicuta mexicana			0										0.000	0.018
Cladium jamaicense	1	0							0				0.167	0.058
Cyperus odorata											0		0.000	0.018
Decodon verticillata						1	0				3		0.500	0.105
Eleocharis baldwinii											0		0.000	0.018
Galium tinctorium			0										0.000	0.018
Habinaria repens			0				0				0		0.000	0.053
Hydrocotyle ranunculoides			0		0				0				0.000	0.053
Hydrocotyle umbellata			0				1	0	0		0		0.167	0.093
Lemna sp.			1		3								0.667	0.128
Limnobium spongia			2	0			5	0	0		2		1.500	0.279
Mikania scandens	0	0	0		0		0						0.000	0.070
Myrica cerifera					0					0			0.000	0.018
Nuphar luteum	0						0						0.000	0.035
Osmunda cinnamomea	1	0											0.167	0.041
Panicum hemitomon			3	0									0.500	0.087
Peltandra virginica	1				1		0	0	5	0			1.167	0.233
Pontederia cordata									0				0.000	0.018
Polygonum densiflorum	0												0.000	0.018
Polygonum hydropeperoides			0										0.000	0.018
Sagittaria lancifolia									0	0			0.000	0.018
Sagittaria latifolia											0		0.000	0.018
Salix caroliniana			0										0.000	0.018
Salviniana minima							1						0.167	0.041
Sambucus canadensis					0								0.000	0.018
Scirpus californicus			0	0									0.000	0.018
Solidago fistulosa											0		0.000	0.018
Spirodela polyrhiza	2		1		2		0		3				1.333	0.274
Triadenum virginicum							0	0					0.000	0.018
Woodwardia virginica							1	0			0		0.167	0.058
Wolffiella floridana			1		3				0				0.667	0.146

Table A-10 cont.

	Canopy Species Composition and Cover												Species Analysis	
	Site													
	SSa-1A		SSa-1B		SSa-2A		SSa-2B		SSa-3A		SSa-3B		Cover	Importance Value*
Species	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	(2 m^2)	
Shrub coverage determined using separate canopy														
Myrica cerifera	1	0									1	1	0.333	0.360
Salix caroliniana	4	0	6	0	7	0	5	0	3	0			4.167	1.640

* Determined by summing the values of relative frequency and relative coverage for species.

Cover class code, 0 (1-9%), 1 (10-19%), 2 (20-29%), 3 (30-39%), 4 (40-49%), 5 (50-59%), 6 (60-69%), 7 (70-79%), 8 (80-89%), 9 (90-99%)

Site and Community Analysis

	SSa-1A		SSa-1B	SSa-2A		SSa-2B	SSa-3A		SSa-3B
Site species richness (2 m^2)	9		16	9		12	10		11
Average site species richness	11.2								
Community species richness	32								
Simpson's Diversity Index (subcan)	0.82		0.89	0.81		0.79	0.72		0.80
Simpson's Diversity Index (canopy)	0.38		0.00	0.00		0.00	0.00		0.00
Simpson's Diversity Index (subcan)		0.92			0.89			0.87	
Simpson's Diversity Index (canopy)		0.00			0.00			0.43	
Morisita's index of community similarity									
Lake Zone I \ Lake Zone II	0.696		0.880						
Lake Zone I \ Lake Zone III	0.568		0.830						
Lake Zone II \ Lake Zone III	0.627		0.891						

Table A-11. Open Water Community (OWa). Species composition and cover, species analysis, and site and community analysis.

	Species Composition and Cover																		Species Analysis	
	Site																			
	Zone 1, 1996		Zone 1, 1996		Zone 1, 1997		Zone 2, 1996		Zone 2, 1996		Zone 2, 1997		Zone 3, 1996		Zone 3, 1996		Zone 3, 1997			Importance
	OWa-1A		OWa-1B		OWa-1C		OWa-2A		OWa-2B		OWa-2C		OWa-3A		OWa-3B		OWa-3C		Cover	Value*
Species	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	(2 m^2)	
Hydrilla verticillata							9	0	9										2	2.000
Ceratophyllum demersum									0										0	0.000

* Determined by summing the values of relative frequency and relative coverage for species.

Cover class code, 0 (1-9%), 1 (10-19%), 2 (20-29%), 3 (30-39%), 4 (40-49%), 5 (50-59%), 6 (60-69%), 7 (70-79%), 8 (80-89%), 9 (90-99%)

Site and Community Analysis

	OWa-1A	OWa-1B	OWa-1C	OWa-2A	OWa-2B	OWa-2C	OWa-3A	OWa-3B	OWa-3C
Site species richness (2 m^2)	0	0	0	2	2	0	0	0	0
Average site species richness	0.4								
Community species richness	2								

Table A-12. Species identified and the vegetative community in which they were sampled. Community code Organic Island Flotant (FIa), Vegetative Island Flotant (FIb), *Scirpus* Vegetative Marsh Flotant (Fma(S)), *Panicum* Marsh (Fma(P), Vegetative Marsh Flotant (FMb), Organic Marsh Flotant (FMc) , Deep Marsh (DMa), Broad-leaf Shallow Marsh (SMa), Linear-leaf Shallow Marsh (SMb), Scrub-Shrub Swamp (SSa) and Open Water (OWa). Code of substrate association identifies relationship of species to floating or submerged substrate at time of sampling. "F" identifies exclusive association with floating substrates, "S" identifies exclusive association with submerged substrates, "SF" identifies association with both submerged and floating substrates as well as free floating species.

	Community in which species was identified											species community occurrence	substrate association
	FIa	FIb	FMa (P)	FMa (S)	FMb	FMc	DMa	SMa	SMb	SSa	OWa		
Acer rubrum						5						1	SF
Alternanthera philoxeroides	1	2			4	5	6	7	8			7	SF
Amaranthus australis	1		3(P)									1	F
Andropogon glomeratus						5						1	F
Andropogon virginicus	1											1	F
Azolla caroliniana					4	5	6	7	8			5	FF
Bidens laevis	1	2		3(S)	4	5						4	F
Bidens mitis	1			3(S)		5						2	F
Boehmeria cylindrica	1					5		7	8	9		5	SF
Ceratophyllum demersum											10	1	A
Cicuta mexicana	1	2			4	5		7		9		6	SF
Cladium jamaicense					4				8	9		3	S
Cuscuta gronovii					4							1	F
Cyperus odorata	1									9		2	SF
Decodon verticillata					4	5		7	8	9		5	SF
Eichhornia crassipes	1	2										2	F
Eleocharis baldwinii	1					5		7		9		4	F
Erianthus giganteus						5						1	F
Eupatorium capillifolium	1											1	F
Galium tinctorium			3(P)		4	5				9		3	SF
Habenaria repens	1	2	3(P)	3(S)	4	5		7		9		6	F
Hydrilla verticillata											10	1	A
Hydrocotyle ranunculoides	1		3(P)		4	5			8	9		5	F
Hydrocotyle umbellata	1	2		3(S)	4	5	6	7	8	9		8	F
Juncus effusus	1											1	SF
Lemna sp.	1	2	3(P)		4	5	6	7	8	9		8	FF
Limnobium spongia	1	2	3(P)	3(S)	4	5	6	7	8	9		8	F
Ludwigia leptocarpa	1					5						2	F
Mikania scandens	1	2				5				9		4	SF
Myrica cerifera										9		1	S
Nuphar luteum	1	2			4		6	7	8	9		7	SF
Nymphaea odorata							6		8			2	SF
Osmunda cinnamomea										9		1	S
Panicum hemitomon	1	2	3(P)		4	5		7		9		6	SF
Peltandra virginica			3(P)		4			7	8	9		4	SF
Pistia stratiotes	1											1	F
Pluchea purpurascens	1											1	F
Polygonum densiflorum	1	2	3(P)	3(S)	4	5	6	7		9		7	SF
Polygonum hydropeperoides					4			7	8	9		4	SF
Pontederia cordata	1	2			4	5	6	7		9		7	SF
Sacciolepis striata								7				1	S

Table A-12 cont.

	Community in which species was identified											species	
			FMa	FMa								community	substrate
	FIa	FIb	(P)	(S)	FMb	FMc	DMa	SMa	SMb	SSa	OWa	occurrence	association
Sagittaria lancifolia					4	5		7	8	9		5	SF
Sagittaria latifolia	1					5				9		3	F
Salix caroliniana								7		9		2	S
Salvinia minima		2		3(S)	4	5		7	8	9		6	FF
Sambucus canadensis										9		1	S
Scirpus californicus									8	9		2	S
Scirpus cubensis	1	2		3(S)	4	5			8			5	F
Solidago fistulosa	1					5				9		3	F
Spirodela polyrhiza		2	3(P)		4	5		7	8	9		6	FF
Thelypteris thelypteroides						5			8			2	SF
Triadenum virginicum						5				9		2	F
Typha latifolia	1	2				5		7	8			5	SF
Unk Gramineae #3						5						1	F
Unk Gramineae seedling 1	1							7				2	SF
Unk Gramineae seedling 2	1				4							2	F
Utricularia fibrosa		2						7				1	F
Utricularia foliosa						5						1	F
Utricularia inflata							6					1	A
Utricularia macrorhiza							6					1	A
Wolfiella floridana					4	5		7	8	9		5	FF
Woodwardia virginica										9		1	S
Total species identified	31	18	10	8	25	34	11	25	21	32	2		

Total number of species in all communities 62

APPENDIX B

VERTICAL PROFILE CHARACTERIZATION OF SITES SURVEYED

Table B-1. Organic island flotant. Vertical profile of most prominent site features.

	FIa-1A		FIa-1B		FIa-2A		FIa-2B	
prominent feature	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Stems	0	1	~	~	~	~	~	~
Root Mat	1	14	-3	0	-6	7	-3	38
Rhizome, Roots and Muck	14	30	0	20	7	39	38	88
Mat Muck	30	40	~	~	39	98	~	~
Water	40	172	20	126	98	175	88	252
Peat	172	176	~	~	~	~	~	~
Bottom Muck	~	~	126	265	175	350	252	365
Mineral	176	Sand	265	clayey fine sand	350	clayey fine sand	365	clayey fine sand

	FIa-2C		FIa-3A		FIa-3B	
prominent feature	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Stems	~	~	~	~	0	9
Root Mat	0	9	~	~	~	~
Rhizome, Roots and Muck	9	27	~	~	9	66
Mat Muck	~	~	-3	100	~	~
Water	27	132	100	210	66	152
Peat	~	~	~	~	~	~
Bottom Muck	132	311	210	263	152	301
Mineral	311	clayey fine sand	263	clayey fine sand	301	clayey fine sand

Table B-2. Organic marsh flotant. Vertical profile of most prominent site features.

prominent feature	FMc-1A		FMc-1B		FMc-2A	
	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Stems	0	10	0	7	0	17
Roots and Mucky Peat	10	55	7	48	17	50
Roots and Peat	~	~	~	~	~	~
Peat	~	~	~	~	~	~
Roots and Water	~	~	48	62	50	62
Water	55	117	62	91	62	157
Bottom Peat	~	~	~	~	157	216
Bottom Mucky Peat	117	160	91	137	~	~
Mineral	160	clayey sand	137	sandy organic	216	clay

prominent feature	FMc-2B		FMc-3A		FMc-3B	
	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Stems	0	3	0	5	0	3
Roots and Mucky Peat	3	10	~	~	3	40
Roots and Peat	~	~	5	13	~	~
Peat	~	~	13	25	~	~
Roots and Water	10	50	~	~	40	50
Water	50	115	25	107	~	~
Bottom Peat	115	169	107	288	50	307
Bottom Mucky Peat	~	~	~	~	~	~
Mineral	169	fine sandy clay	288	clay	307	fine sandy clay

Table B-3. Vegetative island flotant. Vertical profile of most prominent site features.

	FIb-1A		FIb-1B		FIb-2A	
prominent feature	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Stems	0	8	0	6	0	7
Root Mat	8	16	6	12	7	12
Roots and Water	16	58	12	32	12	74
Peat Mat	~	~	32	69	~	~
Water	58	101	69	96	74	139
Mucky Peat	101	176	96	201	~	~
Bottom Muck	~	~	~	~	139	269
Mineral	176	organic clay	201	organic clay	269	clay

	FIb-2B		FIb-3A		FIb-3B	
prominent feature	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Stems	0	75	0	7	0	3
Root Mat	75	86	7	15	3	49
Roots and Water	86	95	15	46	49	70
Peat Mat	~	~	~	~	~	~
Water	95	173	46	141	70	96
Mucky Peat	173	288	141	315	~	~
Bottom Muck	~	~	~	~	96	233
Mineral	288	sandy clay	315	clayey fine sand	233	clayey fine sand

Table B-4. Vegetative marsh flotant. Vertical profile of most prominent site features.

	FMb-1A		FMb-1B		FMb-2A	
prominent feature	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Stems	0	10	0	5	0	6
Root Mat	10	48	5	34	6	34
Roots and Water	48	78	34	82	34	79
Roots and Mucky Peat	78	100	~	~	~	~
Stem and Water below mat	~	~	~	~	~	~
Bottom Peat	100	408	82	129	~	~
Bottom Mucky Peat	~	~	~	~	79	112
Mineral	408	clay	129	fine sand	112	clayey fine sand

	FMb-2B		FMb-3A		FMb-3B	
prominent feature	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Stems	0	9	0	3	0	10
Root Mat	9	31	3	17	10	16
Roots and Water	31	98	17	127	16	38
Roots and Mucky Peat	~	~	~	~	~	~
Stem and Water below mat	~	~	~	~	38	72
Bottom Peat	~	~	~	~	72	278
Bottom Mucky Peat	98	150	127	265	~	~
Mineral	150	clayey fine sand	265	sand	278	clayey sand

Table B-5. *Scirpus* vegetative marsh flotant. Vertical profile of most prominent site features.

	FMa-1B		FMa-2A		FMa-3B	
prominent feature	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Stems	0	5	0	10	0	2
Root Mat	5	10	10	35	2	26
Roots and Water	10	27	35	71	26	65
Peat Mat	27	89	~	~	~	~
Water below mat	89	94	71	175	40	132
Bottom Muck	94	218	175	350	132	275
Mineral	218	clayey sand	350	clayey fine sand	275	clayey sand

Table B-6. *Panicum* marsh community. Vertical profile of most prominent site features.

prominent feature	FMa-1A		FMa-2B		FMa-3A	
	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Stems	0	12	0	16	0	17
Root Mat	12	27	16	33	17	38
Stem and Water below mat	~	~	33	77	38	48
Bottom Peat	27	41	77	133	48	83
Mineral	41	clayey sand	133	clayey fine sand	83	sandy organic

Table B-7 Broad-leaf shallow marsh community. Vertical profile of most prominent site features.

prominent feature	SMa-1A upper boundary depth, cm	SMa-1A lower boundary depth, cm	SMa-1B upper boundary depth, cm	SMa-1B lower boundary depth, cm	SMa-2A upper boundary depth, cm	SMa-2A lower boundary depth, cm
Water and Culms	0	6	0	8	0	12
Culms and Root Mat	6	20	~	~	12	49
Culms, Roots and Water	20	38	~	~	49	83
Roots, Rhizomes & Mucky peat	~	~	8	65	83	122
Bottom Mucky Peat	38	51	~	~	~	~
Bottom Peat	~	~	65	105	122	207
Mineral	51	clay	105	clayey sand	207	clayey fine sand

prominent feature	SMa-2B upper boundary depth, cm	SMa-2B lower boundary depth, cm	SMa-3A upper boundary depth, cm	SMa-3A lower boundary depth, cm	SMa-3B upper boundary depth, cm	SMa-3B lower boundary depth, cm
Water and Culms	0	5	0	6	0	2
Culms and Root Mat	5	35	6	25	2	11
Culms, Roots and Water	35	91	25	63	11	76
Roots, Rhizomes & Mucky peat	91	152	63	82	76	96
Bottom Mucky Peat	~	~	~	~	~	~
Bottom Peat	152	371	82	238	96	170
Mineral	371	fine sandy clay	238	clay	170	sandy clay

Table B-8. Linear-leaf shallow marsh community. Vertical profile of most prominent site features.

prominent feature	SMb-1A upper boundary depth, cm	SMb-1A lower boundary depth, cm	SMb-1B upper boundary depth, cm	SMb-1B lower boundary depth, cm	SMb-2A upper boundary depth, cm	SMb-2A lower boundary depth, cm
Shoots and Water	0	17	0	21	0	78
Root Mat	~	~	~	~	~	~
Roots and Water	~	~	~	~	~	~
Shoots and Water below mat	~	~	~	~	~	~
Roots, Rhizomes & Mucky Peat	17	63	21	96	78	110
Bottom Peat	63	191	96	335	110	140
Mineral	191	sand	335	fine sandy clay	140	clayey fine sand

prominent feature	SMb-2B upper boundary depth, cm	SMb-2B lower boundary depth, cm	SMb-3A upper boundary depth, cm	SMb-3A lower boundary depth, cm	SMb-3B upper boundary depth, cm	SMb-3B lower boundary depth, cm
Shoots and Water	0	57	0	15	0	6
Root Mat	~	~	15	22	6	11
Roots and Water	~	~	22	47	11	63
Shoots and Water below mat	~	~	47	90	~	~
Roots, Rhizomes & Mucky Peat	57	120	90	102	63	112
Bottom Peat	~	~	102	339	112	362
Mineral	120	sand	339	clayey sand	362	fine sandy clay

Table B-9. Scrub-Shrub swamp community. Vertical profile of most prominent site features.

prominent feature	SSa-1A		SSa-1B		SSa-2A	
	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Stems	~	~	0	8	0	42
Root mat	~	~	8	15	~	~
Roots and Mucky Peat Mat	~	~	~	~	~	~
Water with Stems and Roots	~	~	15	37	~	~
Water below mat	~	~	~	~	~	~
Roots and Mucky Peat	0	35	37	83	42	55
Bottom Mucky Peat	~	~	~	~	55	71
Bottom Peat	35	179	~	~	~	~
Mineral	179	clayey sand	83	fine sandy clay	71	sand

prominent feature	SSa-2B		SSa-3A		SSa-3B	
	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and stems	0	3	0	82	0	5
Root mat	3	8	~	~	~	~
Roots and Mucky Peat Mat	~	~	~	~	5	55
Water with Stems and Roots	8	18	~	~	~	~
Water below mat	~	~	~	~	55	103
Roots and Mucky Peat	18	51	82	111	~	~
Bottom Mucky Peat	51	389	~	~	~	~
Bottom Peat	~	~	111	358	103	181
Mineral	389	sandy organic	358	clay	181	clayey fine sand

Table B-10. Deep marsh community. Vertical profile of most prominent site features.

	DMa-1A		DMa-1B		DMa-1C		DMa-2A	
prominent feature	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Petiols	0	200	0	120	0	99	0	140
Root Mat	~	~	~	~	~	~	~	~
Water, Roots and Petiols	~	~	~	~	~	~	~	~
Submerged Aquatics	~	~	~	~	~	~	140	150
Bottom Peat	~	~	~	~	~	~	~	~
Bottom Muck	200	430	120	272	99	186	150	268
Mineral	430	clayey fine sand	272	fine sand	186	fine sand	268	sandy clay

	DMa-2B		DMa-2C		DMa-3A		DMa-3B	
prominent feature	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm	upper boundary depth, cm	lower boundary depth, cm
Water and Petiols	0	146	0	181	~	~	0	4
Root Mat	~	~	~	~	0	17	4	18
Water, Roots and Petiols	~	~	~	~	17	56	18	49
Submerged Aquatics	~	~	~	~	~	~	~	~
Bottom Peat	~	~	~	~	56	163	49	126
Bottom Muck	146	300	181	285	~	~	~	~
Mineral	300	clay	285	sandy org. clay	163	fine sand	126	fine sandy clay

Table B-11. Open water Communities. Vertical profile of most prominent site features.

prominent feature	OWa-1A upper boundary depth, cm	OWa-1A lower boundary depth, cm	OWa-1B upper boundary depth, cm	OWa-1B lower boundary depth, cm	OWa-1C upper boundary depth, cm	OWa-1C lower boundary depth, cm
Water	0	189	0	191	0	220
Water and Aquatics	~	~	~	~	~	~
Bottom Muck	189	425	191	410	220	410
Mineral	425	clay	410	clayey fine sand	410	fine sandy clay

prominent feature	OWa-2A upper boundary depth, cm	OWa-2A lower boundary depth, cm	OWa-2B upper boundary depth, cm	OWa-2B lower boundary depth, cm	OWa-2C upper boundary depth, cm	OWa-2C lower boundary depth, cm
Water	~	~	~	~	0	208
Water and Aquatics	0	268	0	200	~	~
Bottom Muck	268	397	200	435	208	308
Mineral	397	clayey fine sand	435	sandy clay	308	sandy clay

prominent feature	OWa-3A upper boundary depth, cm	OWa-3A lower boundary depth, cm	OWa-3B upper boundary depth, cm	OWa-3B lower boundary depth, cm	OWa-3B upper boundary depth, cm	OWa-3B lower boundary depth, cm
Water	0	190	0	192	0	169
Water and Aquatics	~	~	~	~	~	~
Bottom Muck	190	400	192	365	169	470
Mineral	400	clayey fine sand	365	clayey fine sand	470	clayey fine sand

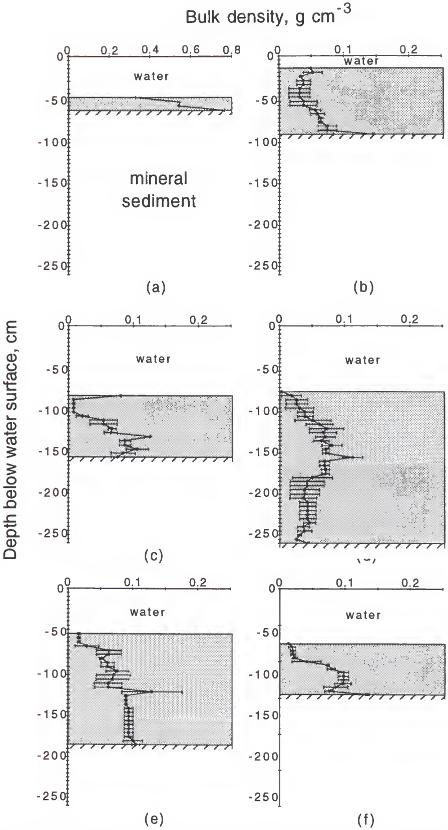


Figure B-1. Sediment density profiles of sites sampled in broad -leaf shallow marsh community. Values are average and one standard deviation of three cores sampled at 5 cm incriments. Sample location and year are a) zone one, 1996; b) zone I, 1997; c) zone II, 1996; d) zone II, 1997; e) zone III, 1996; and f) zone III, 1997.

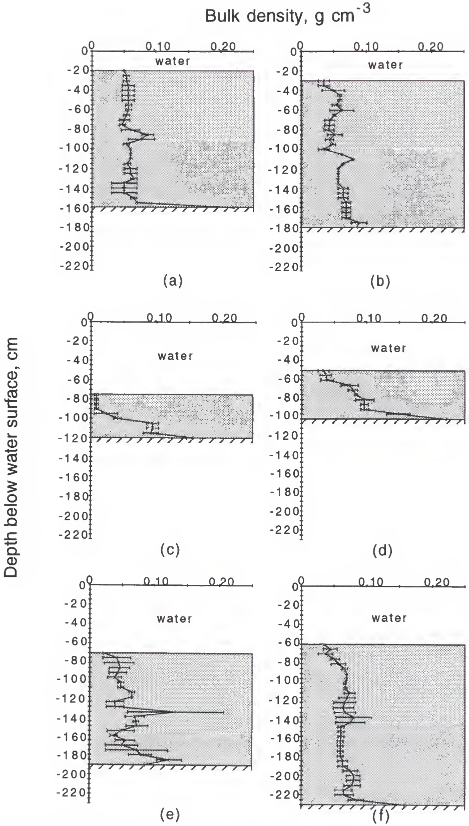


Figure B-2. Sediment density profiles of sites sampled in linear-leaf shallow marsh community. Values are average and one standard deviation of three cores sampled at 5 cm incriments. Sample location and year are a) zone one, 1996; b) zone I, 1997; c) zone II, 1996; d) zone II, 1997; e) zone III, 1996; and f) zone III, 1997.

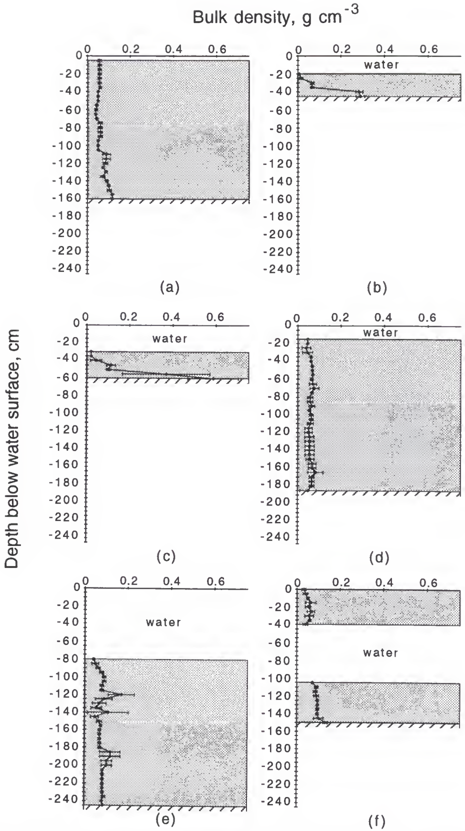


Figure B-3. Sediment density profiles of sites sampled in shrub scrub swamp community. Values are average and one standard deviation of three cores sampled at 5 cm incriments. Sample location and year are a) zone one, 1996; b) zone I, 1997; c) zone II, 1996; d) zone II, 1997; e) zone III, 1996; and f) zone III, 1997.

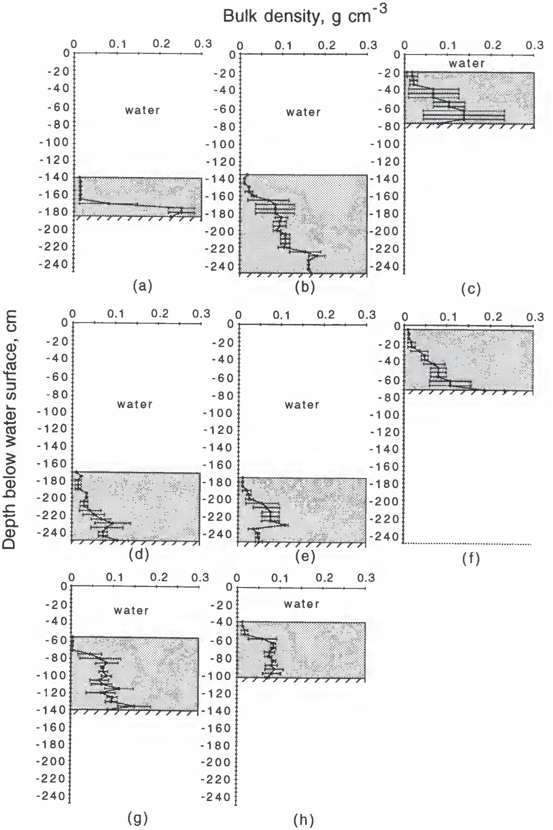


Figure B-4. Sediment density profiles of sites sampled in deep marsh community. Values are average and one standard deviation of three cores sampled at 5 cm incriments. Sample location and year are a) zone I, 1996, b) zone I, 1996; c) zone I, 1997; d) zone II, 1996; e) zone II, 1996; f) zone II, 1997; g) zone III, 1996; and h) zone III, 1997.

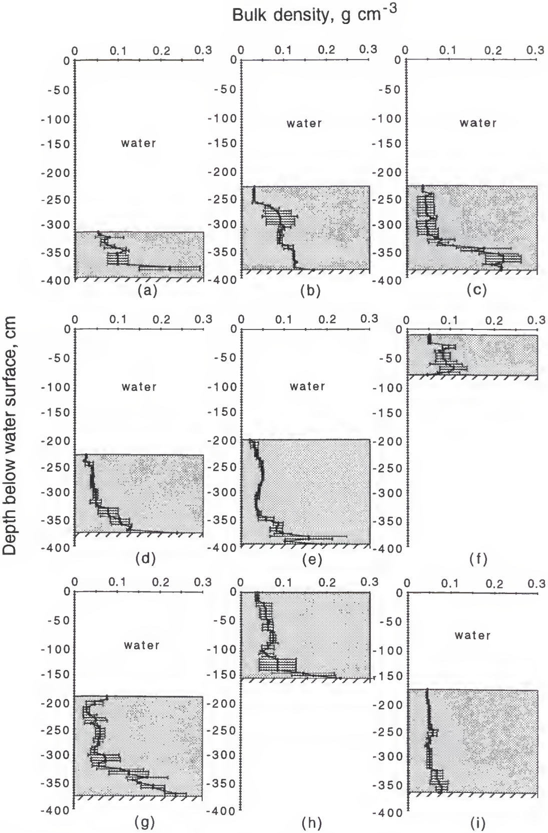


Figure B-5. Sediment density profiles of sites sampled in open water community. Values are average and one standard deviation of three cores sampled at 5 cm incriments. Sample location and year are a) zone I, 1996; b) zone I, 1996; c) zone I, 1997; d) zone II, 1996; e) zone II, 1996; f) zone II, 1997; g) zone III, 1996; and h) zone III, 1997.

APPENDIX C

CALCULATION OF BUOYANCY AND COMMUNITY BUOYANCY COMPONENTS

Calculation of Buoyancy Components

(NSB) Net site buoyancy

$$NSB = BA + RR + G - LB - DB - SW - OS - MS$$

where:

NSB = Net Site Buoyancy
BA = Biomass below-water but above the substrate (kg/m^2)
RR = Root and Rhizome biomass (kg/m^2)
G = Gases (kg/m^2)
LB = Live above-water biomass (kg/m^2)
DB = Dead above-water biomass (kg/m^2)
SW = Sediment and water above the water surface (kg/m^2)
OS = Organic sediments below-water (kg/m^2)
MS = Mineral sediments below-water (kg/m^2)

(BA) Shoot and Stem Biomass below-water but above the substrate

$$BA = (BA_v - BA_m)^* A_q$$

where:

BA = Biomass below-water but above the substrate (kg/m^2)
BA_v = Volume of biomass below-water but above the substrate (kg)
BA_m = Fresh weight of biomass below-water but above the substrate (kg)
A_q = fractional area of the quadrat sampled (m^2)

(RR) Root and Rhizome biomass

$$RR = ((RR_{v1} - RR_{m1}) + (RR_{v2} - RR_{m2}) + (RR_{v3} - RR_{m3})) * 1 / (A_c * 3)$$

where:

RR = Biomass below-water but above the substrate (kg/m^2)
RR_{vi} = Core volume of root and rhizome biomass (kg)
RR_{mi} = Core fresh weight biomass of root and rhizome (kg)
A_c = is the core area fraction of one square meter (m^2)
i = core replicate

(G) Gases

$$G = (C_{V1} - W_{V1} - OS_{V1} - MS_{V1} - R_{V1}) + (C_{V2} - W_{V2} - OS_{V2} - MS_{V2} - R_{V2}) + (C_{V3} - W_{V3} - OS_{V3} - MS_{V3} - R_{V3})) * 1 / (A_c * 3)$$

where:

G = Gases (kg/m^2)
C_{Vi} = total volume of the core (cm^2)
$C_{vi} = TL - PP - PW * A$

where:

C_{vi} = Total volume of the i core
TL = Total length of core liner (cm)
PP = Position of piston relative to top of liner (cm)
PW = Piston width (cm)
A = equals the crossectional area of the core liner (cm^2)

W_{vi} = Water volume

$$W_{vi} = C_{mt} - CL_m - S_m - R_m$$

where:

W_{vi} = water weight (kg) or water volume (l) assuming density of 1.

C_{mt} = total core weight (kg)

CL_m = core cap and liner weight (kg)

S_m = dry sediment weight (kg)

R_m = dry root weight (kg)

i = core replicate

OS_{Vi} = Volume of Organic Solids (l)

$$OS_{Vi} = OS_m \ / \ OS_d$$

where:

OS_V = volume of organic solids

OS_m = dry weight of organic solids

OS_d = organic particle density

i = core replicate

MS_{Vi} = Volume of Mineral Solids (l)

$$MS_{Vi} = MS_m \ / \ MS_d$$

where:

MS_V = volume of mineral solids (l)

MS_m = dry weight of mineral solids (kg)

MS_d = mineral particle density (2.65 g/cm^3)

i = core replicate

R_{vi} = Root Volume (l)

A_c = is the core area fraction of one square meter (m^2)

(LB) Live Above-water Biomass

$$LB = Lb_t / 2$$

where:

LB = Live biomass (kg/2 m^2)

LB_t = total live biomass collected in quadrat (kg/2 m^2)

(DB) Dead Above-water Biomass

$$DB = Db_t / 2$$

where:

DB = Dead biomass (kg/2 m^2)

DB_t = total dead biomass collected in quadrat (kg/2 m^2)

(SW) Sediment and Water above the water surface

$$SW = SW_s * 1 / A_q$$

where:

SW = weight of sediment and water above the water surface (kg/m^2)

SW_s = weight of sample collected from the quadrat (kg)

A_q = fractional area of one square meter sampled (m^2)

(OS) Organic Sediment

$$OS = ((OS_{v1} - OS_{m1}) + (OS_{v2} - OS_{m2}) + (OS_{v3} - OS_{m3})) * 1 / (A_c * 3)$$

where:

OS_{vi} = volume of organic sediment (kg/m_2)

$$OS_{Vi} = OS_m / OS_d$$

where:

OS_V = volume of organic solids (l)

OS_m = dry weight of organic solids (kg)

OS_d = organic particle density (kg/l)

i = core replicate

OS_{mi} = dry weight of organic sediments (kg)

$$OS_{mi} = ST_m - MS_{mi}$$

where:

St_m = total mass of sediments (kg)

MS_{mi} = Mass of mineral sediment (kg)

A = is the meter fractional area of the core (m_2)

(MS) Mineral Sediment

$$MS = ((MS_{v1} - MS_{m1}) + (MS_{v2} - MS_{m2}) + (MS_{v3} - MS_{m3})) * 1 / (A * 3)$$

where:

MS_{vi}= volume of organic sediment (kg/m^2)

$MS_{vi} = MS_m / MS_d$

where:

MS_v = volume of mineral solids (l)

MS_m = dry weight of organic solids (kg)

MS_d = Mineral particle density (kg/m^2)

i = core replicate

MS_{mi} = Mass of Mineral Sediment (kg)

$MS_{mi} = ST_m * MC$

where:

MS_{mi} = mass of mineral sediment (kg)

ST_m = total sediment mass (kg)

MC = mineral content of sediment

A = is the meter fractional area of the core (m^2)

Calculation of Buoyancy Ratio

(BR) Buoyancy Ratio

$BR = WRB_{aw} / B_{bw}D$

Where:

BR = Buoyancy Ratio

WDB_{aw} = Wet to Dry weight ratio of Biomass above-water (g/g)

$B_{bw}D$ = Biomass below-water Displacement (ml/g)

(WDB) Wet to Dry weight ratio

$WDB_{aw} = WwBaw/WdBaw$

where:

WDB_{aw} = Wet to Dry weight ratio of Biomass above-water (g/g)

W_wB_{aw} = Weight dry of Biomass above-water (g)

W_dB_{aw} = Weight wet of Biomass above-water (g)

(BD) Below Water Biomass Displacement:

$B_{bw}D = (VB_{bw} - W_wB_{bw})/W_dB_{bw}$

where:

$B_{bw}D$ = Biomass below-water Displacement (ml/g)

VB_{bw} = Volume of Biomass below-water (ml)

W_wB_{bw} = Weight wet of Biomass below-water (g)

W_dB_{bw} = Weight dry of Biomass below-water (g)

Table C-1. Panicum marsh. Columns titled "percentage of buoyancy" represent percentage component contributed to either positive or negative buoyancy.

Site Totals

buoyancy component	FMa-1A buoyancy kg/m2	FMa-1A % of buoyancy	FMa-2B buoyancy kg/m2	FMa-2B % of buoyancy	FMa-3A buoyancy kg/m2	FMa-3A % of buoyancy
Above-water						
Live Biomass (-)	-2.78	17.48	-1.92	8.66	-1.78	35.81
Dead Biomass (-)	0.00	0.00	-0.52	2.35	-0.98	19.72
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00
Below-water						
Organic Sediment (-)	-11.29	71.01	-12.14	54.78	-1.43	28.77
Mineral Sediment (-)	-1.83	11.51	-7.58	34.21	-0.78	15.69
Stem and Shoot Biomass (+)	0.85	4.89	2.98	13.72	0.00	0.00
Root and Rhizome Biomass (+)	0.36	2.07	0.98	4.51	1.86	19.54
Gases (+)	16.18	93.04	17.76	81.77	7.66	80.46
Net Site Buoyancy	1.49		-0.44		4.55	

Community Summary

buoyancy component	buoyancy kg/m2 Mean	SD	Min	Max	percent of buoyancy Mean	SD
Above-water						
Live Biomass (-)	-2.16	0.44	-2.78	-1.78	20.65	11.31
Dead Biomass (-)	-0.50	0.40	-0.98	0.00	7.35	8.79
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00
Below-water						
Organic Sediment (-)	-8.29	4.86	-12.14	-1.43	51.52	17.40
Mineral Sediment (-)	-3.40	2.99	-7.58	-0.78	20.47	9.86
Stem and Shoot Biomass (+)	1.28	1.25	0.00	2.98	6.20	5.68
Root and Rhizome Biomass (+)	1.07	0.62	0.36	1.86	8.71	7.72
Gases (+)	13.87	4.44	7.66	17.76	85.09	5.65
Net Site Buoyancy	1.87	2.05				

Table C-2. Broad-leaf Shallow Marsh. Columns titled "percentage of buoyancy" represent percentage component contributed to either positive or negative buoyancy.

Site Totals

	SMa-1A		SMa-1B		SMa-2A	
buoyancy component	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy
Above-water						
Live Biomass (-)	-2.58	5.15	-3.87	27.90	-1.20	11.80
Dead Biomass (-)	-0.49	0.98	-1.02	7.35	-0.19	1.87
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00
Below-water						
Organic Sediment (-)	-8.73	17.41	-8.32	59.99	-8.78	86.33
Mineral Sediment (-)	-38.33	76.46	-0.66	4.76	0.00	0.00
Stem and Shoot Biomass (+)	4.07	36.97	0.00	0.00	9.87	23.36
Root and Rhizome Biomass (+)	0.15	1.36	1.98	5.48	1.25	2.96
Gases (+)	6.79	61.67	34.18	94.52	31.13	73.68
Net Site Buoyancy	-39.12		22.29		32.08	

	SMa-2B		SMa-3A		SMa-3B	
buoyancy component	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy
Above-water						
Live Biomass (-)	-2.58	13.14	-2.54	8.92	-1.74	13.42
Dead Biomass (-)	-0.29	1.48	-1.48	5.19	-0.45	3.47
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00
Below-water						
Organic Sediment (-)	-16.48	83.95	-24.47	85.89	-10.42	80.34
Mineral Sediment (-)	-0.28	1.43	0.00	0.00	-0.36	2.78
Stem and Shoot Biomass (+)	5.68	12.47	6.39	12.06	3.06	9.94
Root and Rhizome Biomass (+)	0.69	1.52	3.17	5.98	0.63	2.05
Gases (+)	39.17	86.01	43.43	81.96	27.10	88.02
Net Site Buoyancy	25.91		24.50		17.82	

Community Summary

	buoyancy kg/m2				percent of buoyancy	
buoyancy component	Mean	SD	Min	Max	Mean	SD
Above-water						
Live Biomass (-)	-2.42	0.83	-3.87	-1.20	13.39	7.08
Dead Biomass (-)	-0.65	0.45	-1.48	-0.19	3.39	2.26
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00
Below-water						
Organic Sediment (-)	-12.87	5.89	-24.47	-8.32	68.99	24.77
Mineral Sediment (-)	-6.61	14.19	-38.33	0.00	14.24	27.88
Stem and Shoot Biomass (+)	4.85	3.04	0.00	9.87	15.80	11.65
Root and Rhizome Biomass (+)	1.31	1.01	0.15	3.17	3.22	1.85
Gases (+)	30.30	11.76	6.79	43.43	80.98	10.69
Net Site Buoyancy	11.93	24.10				
Net Buoyancy without SMa-1A	24.52	4.67				

Table C-3. Linear-leaf Shallow Marsh. Columns titled "percentage of buoyancy" represent percentage component contributed to either positive or negative buoyancy.

Site Totals

	SMb-1A		SMb-1B		SMb-2A	
buoyancy component	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy
Above-water						
Live Biomass (-)	-2.18	10.24	-2.16	12.44	-1.02	10.92
Dead Biomass (-)	-1.40	6.58	-1.38	7.94	-0.82	8.78
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00
Below-water						
Organic Sediment (-)	-16.59	77.96	-13.71	78.93	-5.60	59.96
Mineral Sediment (-)	-1.11	5.22	-0.12	0.69	-1.90	20.34
Stem and Shoot Biomass (+)	2.62	8.24	0.76	1.67	4.62	22.68
Root and Rhizome Biomass (+)	3.10	9.75	4.23	9.29	0.46	2.26
Gases (+)	26.09	82.02	40.53	89.04	15.29	75.06
Net Site Buoyancy	10.53		28.15		11.03	

	SMb-2B		SMb-3A		SMb-3B	
buoyancy component	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy
Above-water						
Live Biomass (-)	-4.87	34.18	-2.31	12.64	-1.56	6.78
Dead Biomass (-)	-0.67	4.70	-0.93	5.09	-0.66	2.87
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00
Below-water						
Organic Sediment (-)	-7.90	55.44	-15.04	82.28	-20.74	90.17
Mineral Sediment (-)	-0.81	5.68	0.00	0.00	-0.04	0.17
Stem and Shoot Biomass (+)	6.16	24.06	2.78	11.83	3.43	7.86
Root and Rhizome Biomass (+)	1.17	4.57	2.64	11.24	2.51	5.75
Gases (+)	18.27	71.37	18.07	76.93	37.69	86.39
Net Site Buoyancy	11.35		5.21		20.63	

Community Summary

	buoyancy kg/m2				percent of buoyancy	
buoyancy component	Mean	SD	Min	Max	Mean	SD
Above-water						
Live Biomass (-)	-2.35	1.21	-4.87	-1.02	14.53	9.76
Dead Biomass (-)	-0.98	0.31	-1.40	-0.66	5.99	2.80
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00
Below-water						
Organic Sediment (-)	-13.26	5.13	-20.74	-5.60	74.12	28.34
Mineral Sediment (-)	-0.66	0.69	-1.90	0.00	5.35	6.83
Stem and Shoot Biomass (+)	3.40	1.69	0.76	6.16	12.72	8.73
Root and Rhizome Biomass (+)	2.35	1.24	0.46	4.23	7.14	3.86
Gases (+)	25.99	9.88	15.29	40.53	80.13	28.63
Net Site Buoyancy	14.48	7.61				

Table C-4. Scrub-Shrub Swamp Community. Columns titled "percentage of buoyancy" represent percentage component contributed to either positive or negative buoyancy.

Site Totals

buoyancy component	SSa-1A buoyancy kg/m2	SSa-1A % of buoyancy	SSa-1B buoyancy kg/m2	SSa-1B % of buoyancy	SSa-2A buoyancy kg/m2	SSa-2A % of buoyancy
Above-water						
Live Biomass (-)	-0.25	0.74	-0.73	1.39	-0.17	1.02
Dead Biomass (-)	-0.20	0.59	-0.07	0.13	0.00	0.00
Water and Sediment (-)	-11.58	34.17	0.00	0.00	0.00	0.00
Below-water						
Organic Sediment (-)	-21.79	64.30	-7.44	14.12	-13.14	78.87
Mineral Sediment (-)	0.00	0.00	-44.46	84.36	-3.35	20.11
Stem and Shoot Biomass (+)	0.00	0.00	1.05	6.21	0.84	5.75
Root and Rhizome Biomass (+)	-0.07	0.21	0.35	2.07	0.19	1.30
Gases (+)	37.98	100.00	15.50	91.72	13.59	92.95
Net Site Buoyancy	4.09		-35.80		-2.04	

buoyancy component	SSa-2B buoyancy kg/m2	SSa-2B % of buoyancy	SSa-3A buoyancy kg/m2	SSa-3A % of buoyancy	SSa-3B buoyancy kg/m2	SSa-3B % of buoyancy
Above-water						
Live Biomass (-)	-2.02	9.05	-1.20	3.79	-1.28	8.16
Dead Biomass (-)	-0.21	0.94	-0.02	0.06	-0.28	1.78
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00
Below-water						
Organic Sediment (-)	-18.96	84.91	-30.47	96.15	-13.73	87.51
Mineral Sediment (-)	-1.14	5.11	0.00	0.00	-0.40	2.55
Stem and Shoot Biomass (+)	0.00	0.00	5.16	11.41	0.00	0.00
Root and Rhizome Biomass (+)	0.20	0.54	0.35	0.77	0.37	1.06
Gases (+)	36.62	99.46	39.72	87.82	34.49	98.94
Net Site Buoyancy	14.49		13.54		19.17	

Community Summary

buoyancy component	buoyancy kg/m2 Mean	SD	Min	Max	percent of buoyancy Mean	SD
Above-water						
Live Biomass (-)	-0.94	0.64	-2.02	-0.17	4.02	3.44
Dead Biomass (-)	-0.13	0.11	-0.28	0.00	0.59	0.62
Water and Sediment (-)	-1.93	4.32	-11.58	0.00	5.69	11.96
Below-water						
Organic Sediment (-)	-17.59	7.34	-30.47	-7.44	70.98	35.37
Mineral Sediment (-)	-8.23	16.25	-44.46	0.00	18.69	28.68
Stem and Shoot Biomass (+)	1.18	1.83	0.00	5.16	3.89	4.20
Root and Rhizome Biomass (+)	0.23	0.15	-0.07	0.37	0.99	0.65
Gases (+)	29.65	10.81	13.59	39.72	95.15	33.57
Net Site Buoyancy	2.24	18.41				
Net Buoyancy without SSa-1B	9.85	7.70				

Table C-5. Deep Marsh Community. Columns titled "percentage of buoyancy" represent percentage component contributed to either positive or negative buoyancy.

Site Totals

buoyancy component	DMa-1A buoyancy kg/m2	DMa-1A % of buoyancy	DMa-1B buoyancy kg/m2	DMa-1B % of buoyancy	DMa-1C buoyancy kg/m2	DMa-1C % of buoyancy	DMa-2A buoyancy kg/m2	DMa-2A % of buoyancy
Above-water								
Live Biomass (-)	-0.07	0.26	-0.27	1.23	-1.45	9.16	-0.09	0.76
Dead Biomass (-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below-water								
Organic Sediment (-)	-8.93	33.76	-14.64	66.45	-10.67	67.40	-11.31	94.96
Mineral Sediment (-)	-17.45	65.97	-7.12	32.32	-3.71	23.44	-0.51	4.28
Stem and Shoot Biomass (+)	1.89	6.69	15.66	31.33	0.88	2.09	24.61	49.51
Root and Rhizome Biomass (+)	0.00	0.00	9.60	19.21	16.75	39.73	8.86	17.82
Gases (+)	26.38	93.31	24.72	49.46	24.53	58.18	16.24	32.67
Net Site Buoyancy	1.82		27.95		26.33		37.80	

buoyancy component	DMa-2B buoyancy kg/m2	DMa-2B % of buoyancy	DMa-2C buoyancy kg/m2	DMa-2C % of buoyancy	DMa-3A buoyancy kg/m2	DMa-3A % of buoyancy	DMa-3B buoyancy kg/m2	DMa-3B % of buoyancy
Above-water								
Live Biomass (-)	-0.13	0.84	-0.80	17.70	-1.30	4.77	-1.31	8.63
Dead Biomass (-)	0.00	0.00	0.00	0.00	-0.05	0.18	-0.02	0.13
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below-water								
Organic Sediment (-)	-12.05	77.44	-3.72	82.30	-13.88	50.95	-12.54	82.61
Mineral Sediment (-)	-3.38	21.72	0.00	0.00	-12.01	44.09	-1.31	8.63
Stem and Shoot Biomass (+)	23.73	46.82	4.10	16.02	3.36	8.73	2.43	7.00
Root and Rhizome Biomass (+)	9.06	17.88	1.25	4.88	0.30	0.78	2.91	8.38
Gases (+)	17.89	35.30	20.25	79.10	34.82	90.49	29.38	84.62
Net Site Buoyancy	35.12		21.08		11.24		19.54	

Community Summary

buoyancy component	buoyancy kg/m2 Mean	buoyancy kg/m2 SD	buoyancy kg/m2 Min	buoyancy kg/m2 Max	percent of buoyancy Mean	percent of buoyancy SD
Above-water						
Live Biomass (-)	-0.68	0.57	-1.45	-0.07	5.42	5.73
Dead Biomass (-)	-0.01	0.02	-0.05	0.00	0.04	0.07
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00
Below-water						
Organic Sediment (-)	-10.97	3.21	-14.64	-3.72	69.49	18.31
Mineral Sediment (-)	-5.69	5.79	-17.45	0.00	25.06	20.71
Stem and Shoot Biomass (+)	9.58	9.47	0.88	24.61	21.02	17.75
Root and Rhizome Biomass (+)	6.09	5.55	0.00	16.75	13.59	12.26
Gases (+)	24.28	5.74	16.24	34.82	65.39	23.05
Net Site Buoyancy	22.61	11.20				

Table C-6. Open Water Community. Columns titled "percentage of buoyancy" represent percentage component contributed to either positive or negative buoyancy.

Site Totals

	OWa-1A		OWa-1B		OWa-1C		OWa-2A		OWa-2B	
buoyancy component	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy
Above-water										
Live Biomass (-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dead Biomass (-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below-water										
Organic Sediment (-)	-21.79	44.82	-19.54	78.73	-28.00	72.58	-13.18	55.40	-23.14	90.53
Mineral Sediment (-)	-26.83	55.18	-5.28	21.27	-10.58	27.42	-10.61	44.60	-2.42	9.47
Stem and Shoot Biomass (+)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Root and Rhizome Biomass (+)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gases (+)	20.15	100.00	25.78	100.00	33.50	100.00	15.81	100.00	24.94	100.00
Net Site Buoyancy	-28.47		0.96		-5.08		-7.98		-0.62	

	OWa-2C		OWa-3A		OWa-3B		OWa-3C	
buoyancy component	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy	buoyancy kg/m2	% of buoyancy
Above-water								
Live Biomass (-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dead Biomass (-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below-water								
Organic Sediment (-)	-12.54	74.47	-40.66	100.00	-16.59	82.54	-27.26	99.67
Mineral Sediment (-)	-4.30	25.53	0.00	0.00	-3.51	17.46	-0.09	0.33
Stem and Shoot Biomass (+)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Root and Rhizome Biomass (+)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gases (+)	22.97	100.00	35.85	100.00	19.68	100.00	43.05	100.00
Net Site Buoyancy	6.13		-4.81		-0.42		15.70	

Community Summary

	buoyancy kg/m2				percent of buoyancy	
buoyancy component	Mean	SD	Min	Max	Mean	SD
Above-water						
Live Biomass (-)	0.00	0.00	0.00	0.00	0.00	0.00
Dead Biomass (-)	0.00	0.00	0.00	0.00	0.00	0.00
Water and Sediment (-)	0.00	0.00	0.00	0.00	0.00	0.00
Below-water						
Organic Sediment (-)	-22.52	8.26	-40.66	0.00	77.64	17.59
Mineral Sediment (-)	-7.07	7.88	-26.83	0.00	22.36	17.59
Stem and Shoot Biomass (+)	0.00	0.00	0.00	0.00	0.00	0.00
Root and Rhizome Biomass (+)	0.00	0.00	0.00	0.00	0.00	0.00
Gases (+)	26.86	8.34	15.81	43.05	100.00	0.00
Net Site Buoyancy	-2.73	11.26				
Net Buoyancy without OWa-1A	0.49	7.04				

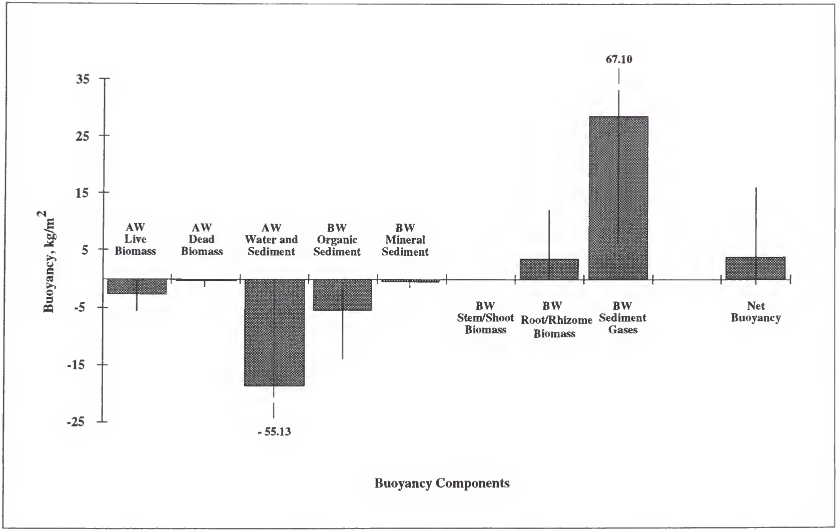


Figure C-1. Average and range of buoyancy values calculated from sites sampled in organic island flotant. "AW" indicates buoyancy components above-water, "BW" indicates buoyancy components below-water.

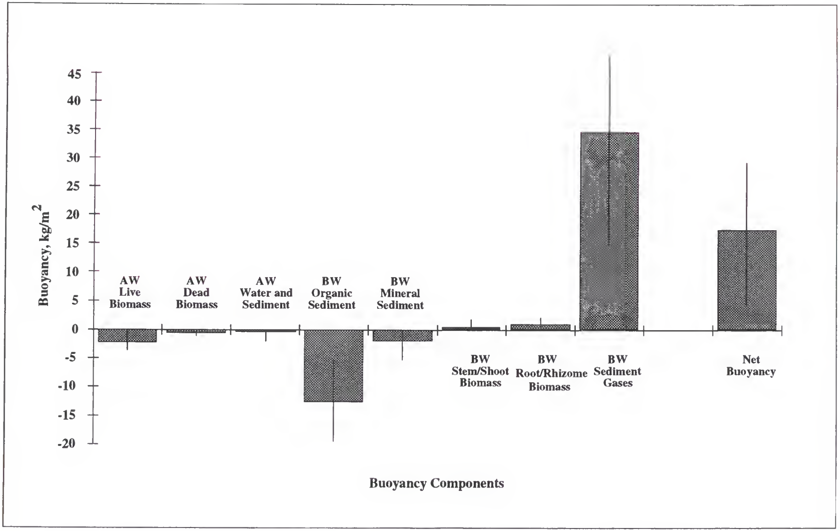


Figure C-2. Average and range of buoyancy values calculated from sites sampled in Organic Marsh Flotant communities type FMc. "AW" indicates buoyancy components above-water, "BW" indicates buoyancy components below-water.

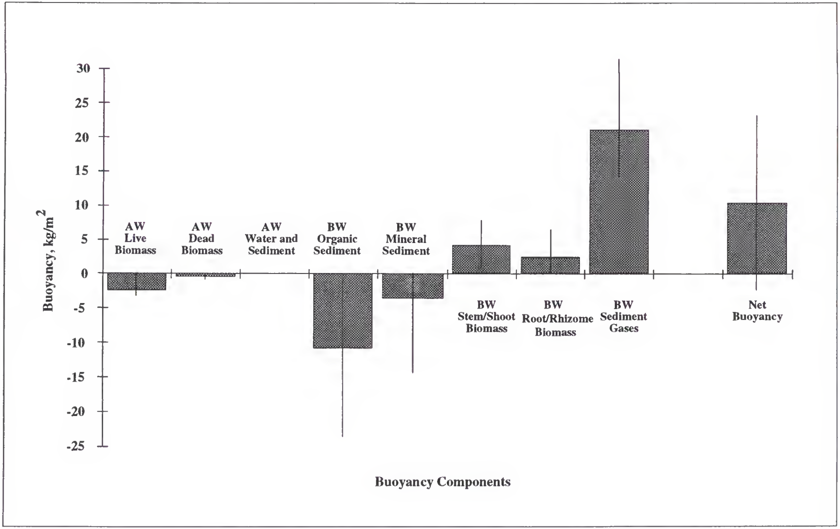


Figure C-4. Average and range of buoyancy values calculated from sites sampled in Vegetative Marsh Flotant communities type FMb. "AW" indicates buoyancy components above-water, "BW" indicates buoyancy components below-water.

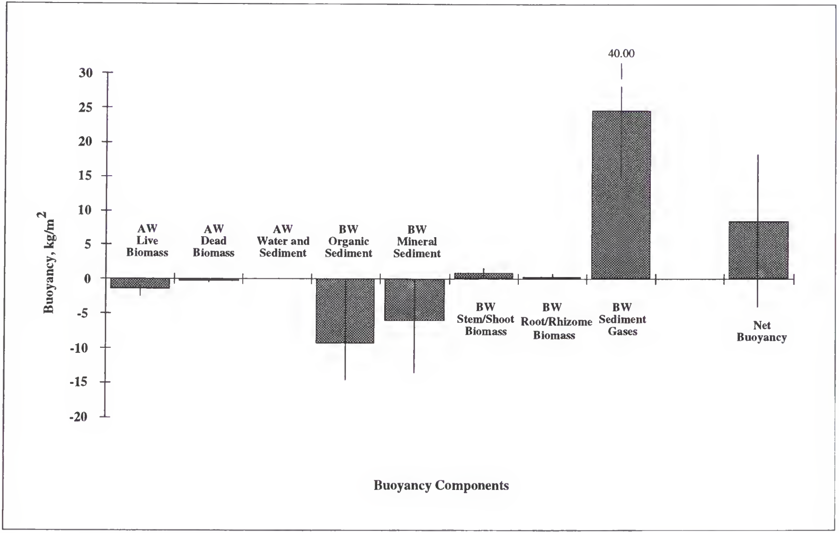


Figure C-5. Average and range of buoyancy values calculated from sites sampled in *Scirpus* Vegetative Marsh Flotant. "AW" indicates buoyancy components above-water, "BW" indicates buoyancy components below-water.

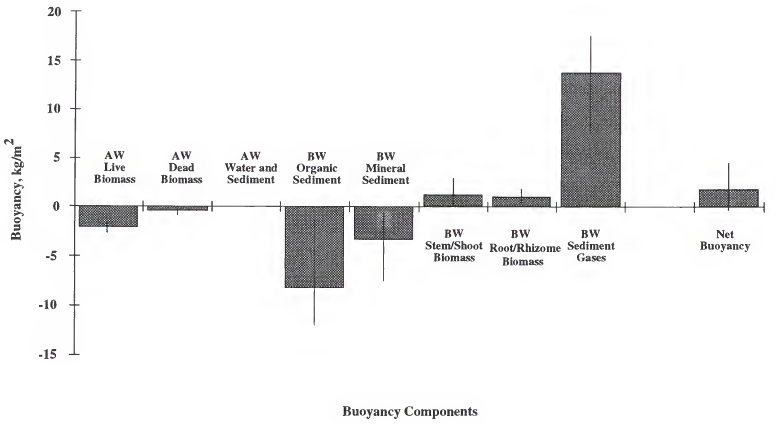


Figure C-6. Average and range of buoyancy values calculated from sites sampled in *Panicum* Marsh communities. "AW" indicates buoyancy components above-water, "BW" indicates buoyancy components below-water.

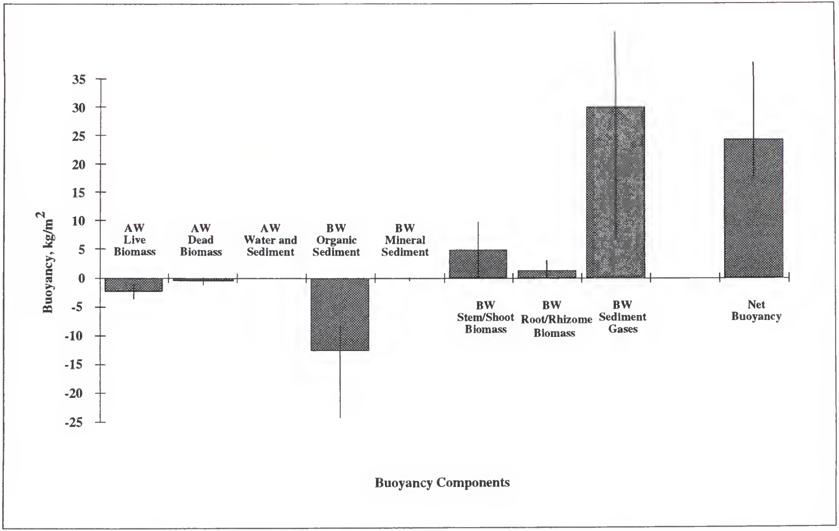


Figure C-7. Average and range of buoyancy values calculated from sites sampled in Broad-leaf Shallow Marsh communities type SMa. Buoyancy values for below-water mineral sediments from site SMa-1A were not used in the average or range in this graph due to the high mineral content in the sample resulting from excessive penitration of the bottom sediments during coring. "AW" indicates buoyancy components above-water, "BW" indicates buoyancy components below-water.

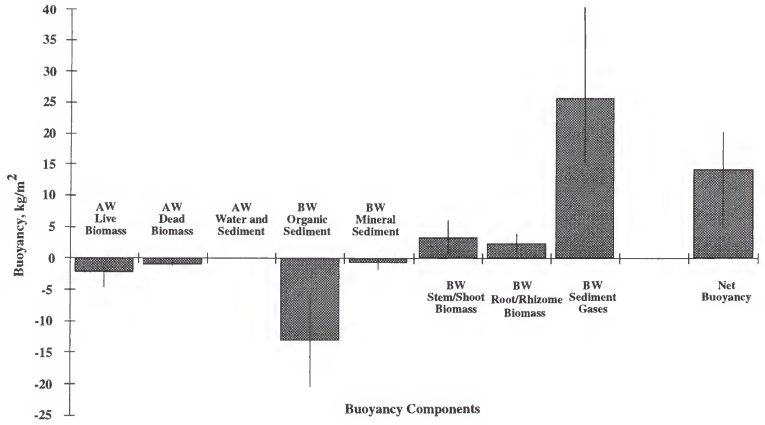


Figure C-8. Average and range of buoyancy values calculated from sites sampled in Linear-leaf Shallow Marsh communities type SMb. "AW" indicates buoyancy components above-water, "BW" indicates buoyancy components below-water.

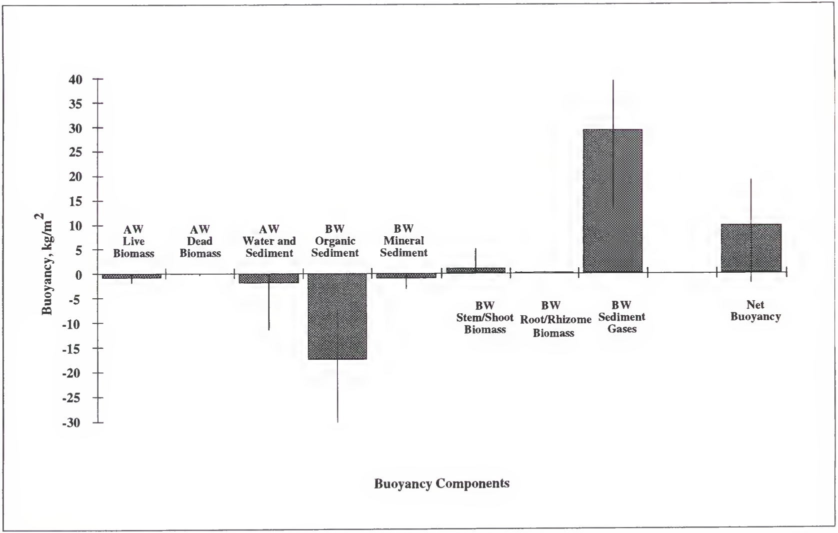


Figure C-9. Average and range of buoyancy values calculated from sites sampled in Floating Island communities type SSa. Buoyancy values for below-water mineral sediments from site SSa-1B were not used in the average or range in this graph due to the high mineral content in the sample resulting from excessive penitration of the bottom sediments during coring. "AW" indicates buoyancy components above-water, "BW" indicates buoyancy components below-water.

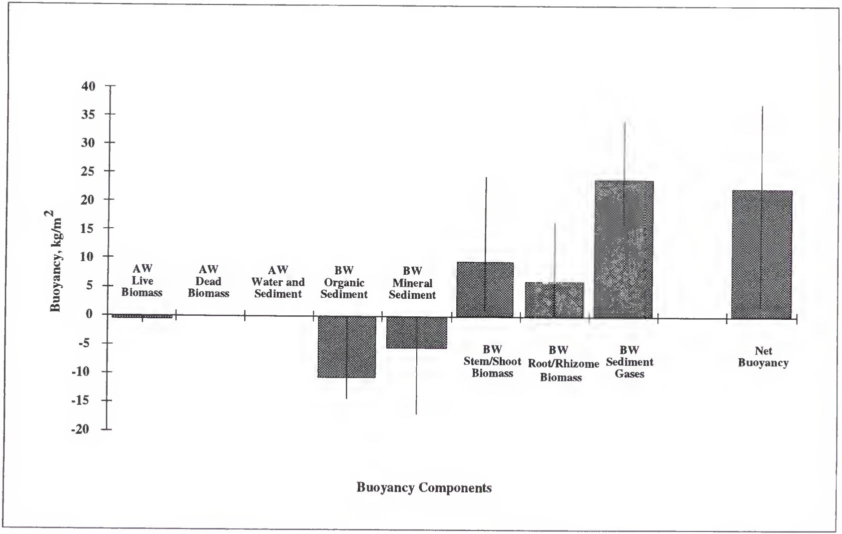


Figure C-10. Average and range of buoyancy values calculated from sites sampled in Deep Marsh communities type DMa. "AW" indicates buoyancy components above-water, "BW" indicates buoyancy components below-water.

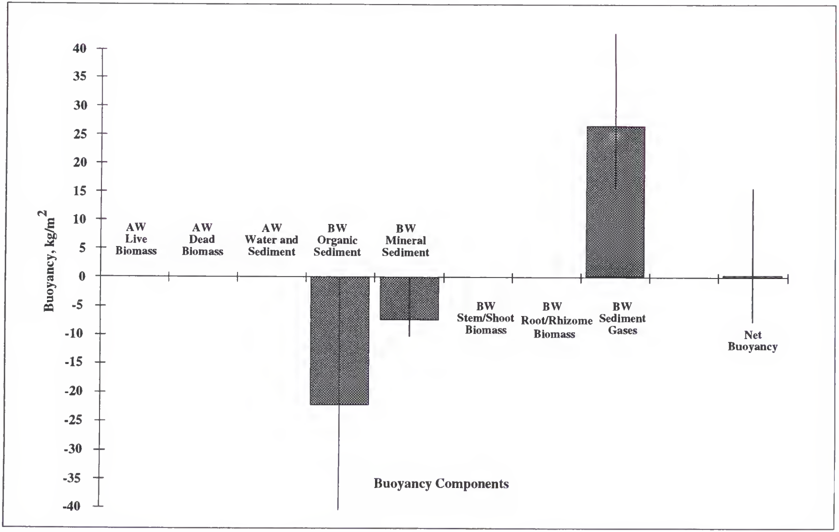


Figure C-11. Average and range of buoyancy values calculated from sites sampled in Open Water communities type OWa. Buoyancy values for below-water mineral sediments from site OWa-1A were not used in the average or range in this graph due to the high mineral content in the sample resulting from excessive penitration of the bottom sediments during coring. "AW" indicates buoyancy components above-water, "BW" indicates buoyancy components below-water.

APPENDIX D

PEAT STRATIGRAPHY OF SITES SURVEYED
AND
PEAT CHARACTERIZATION OF SITES SURVEYED

Table D-1. Latitude and longitude coordinates of sampling sites.

Site Code	Sampling Date	Latitude	Longitude
Floating Island community type FIa			
FIa-1A	10/18/96	29° 28.833′ N	82° 12.284′ W
FIa-2A	11/7/96	29° 26.389′ N	82° 11.443′ W
FIa-3A	9/16/96	29° 25.818′ N	82° 09.059′ W
Floating Island community type FIb			
FIb-1A	11/18/96	29° 29.355′ N	82° 12.950′ W
FIb-3A	10/21/96	29° 26.415′ N	82° 07.945′ W
Floating Marsh community type FMa			
FMa-1A	9/21/96	29° 28.888′ N	82° 12.555′ W
FMa-2A	11/8/96	29° 26.180′ N	82° 10.457′ W
FMa-3A	10/21/96	29° 26.409′ N	82° 08.916′ W
Floating Marsh community type FMb			
FMb-1A	10/23/96	29° 29.900′ N	82° 13.180′ W
FMb-2A	10/4/96	29° 26.976′ N	82° 11.089′ W
FMb-3A	11/10/96	29° 26.570′ N	82° 08.902′ W
Floating Marsh community type FMc			
FMc-1A	10/30/96	29° 28.828′ N	82° 12.335′ W
FMc-2A	10/11/96	29° 25.876′ N	82° 11.263′ W
FMc-3A	11/12/96	29° 26.606′ N	82° 06.732′ W
Deep Marsh community type DMa			
DMa-1A	8/23/96	29° 29.368′ N	82° 11.380′ W
DMa-2A	8/9/96	29° 26.868′ N	82° 11.919′ W
DMa-3A	8/30/96	29° 27.058′ N	82° 07.258′ W
Shallow Marsh community type SMa			
SMa-1A	9/9/96	29° 30.345′ N	82° 12.161′ W
SMa-2A	9/4/96	29° 25.758′ N	82° 09.911′ W
SMa-3A	11/15/96	29° 26.488′ N	82° 08.349′ W
Shallow Marsh community type SMb			
SMb-1A	10/12/96	29° 30.481′ N	82° 13.112′ W
SMb-2A	11/16/96	29° 27.095′ N	82° 11.568′ W
SMb-3A	11/3/96	29° 27.066′ N	82° 07.556′ W
Shrub Swamp community type SSa			
SSa-1A	11/18/96	29° 30.672′ N	82° 13.598′ W
SSa-2A	11/5/96	29° 26.210′ N	82° 12.624′ W
SSa-3A	10/14/96	29° 26.412′ N	82° 07.270′ W

Table D-1 cont. Latitude and longitude coordinates of sampling sites.

Site Code	Sampling Date	Latitude	Longitude
Open Water community type OWa			
OWa-1B	8/14/96	29° 28.423′ N	82° 12.059′ W
OWa-2A	8/5/96	29° 26.193′ N	82° 12.208′ W
OWa-3B	7/19/96	29° 25.867′ N	82° 09.276′ W

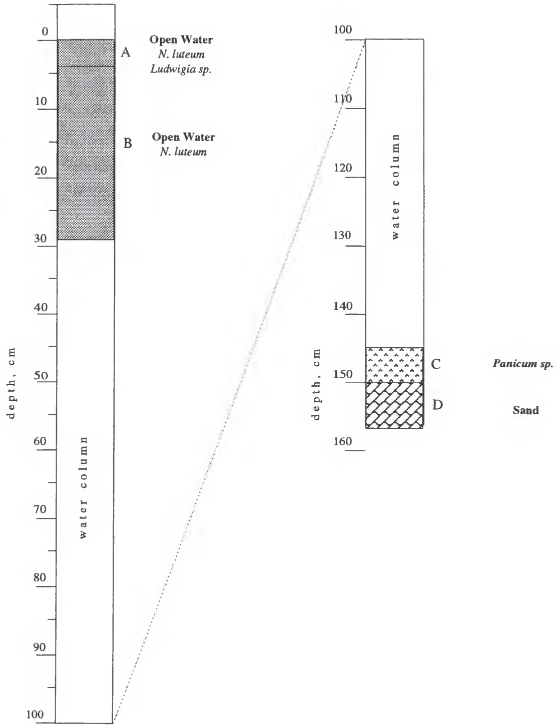


Figure D-1. Peat stratigraphy of site Fla-1A, organic base island flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

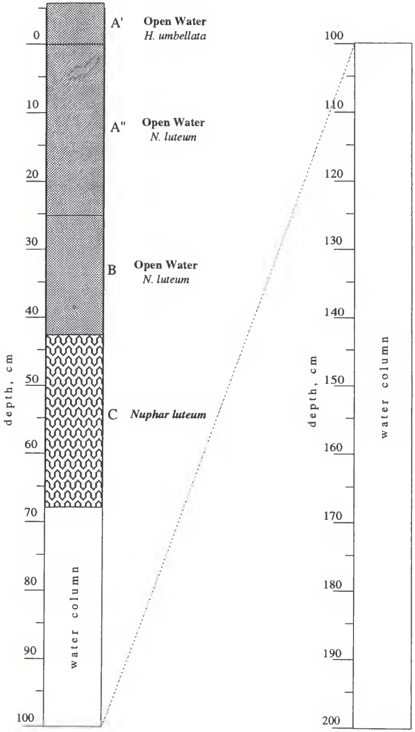


Figure D-2a Peat stratigraphy of site Fla-2A, organic base island flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

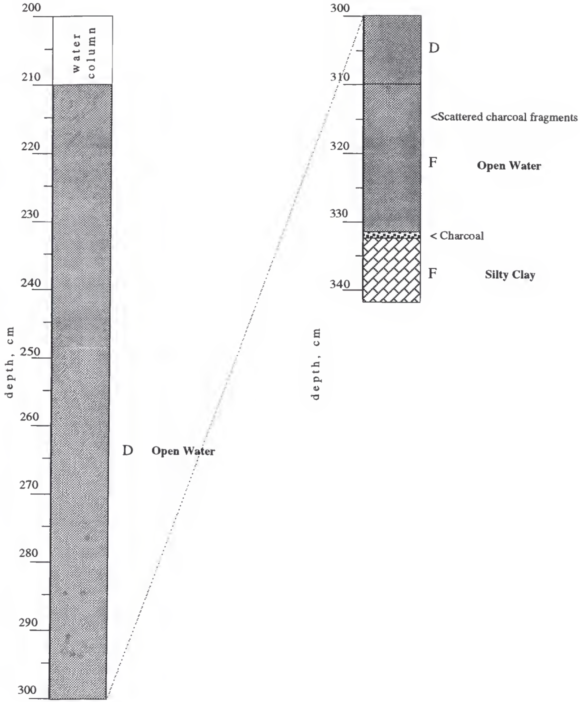


Figure D-2b. Peat stratigraphy of site FIa-2A, organic base island flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

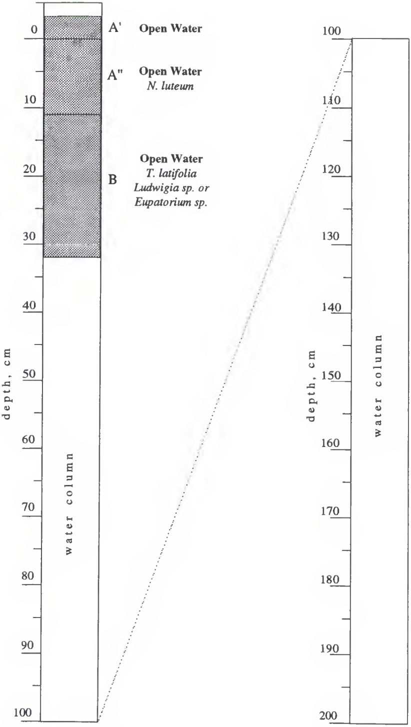


Figure D-3a Peat stratigraphy of site Fla-2B, organic base island flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

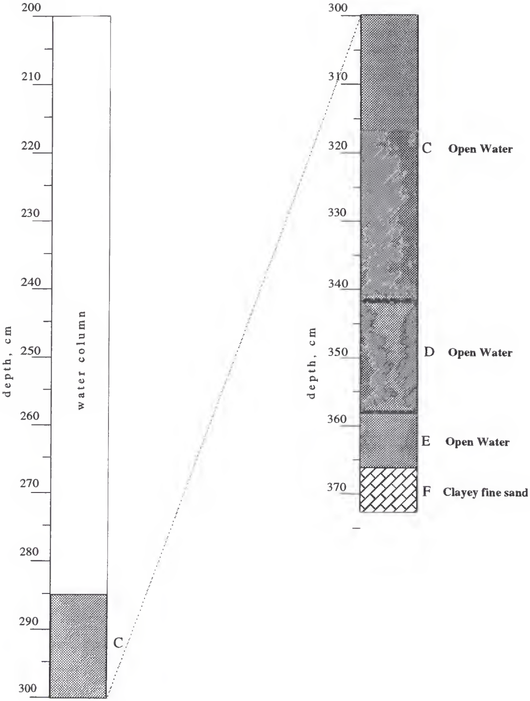


Figure D-3b. Peat stratigraphy of site Fla-2B, organic base island flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

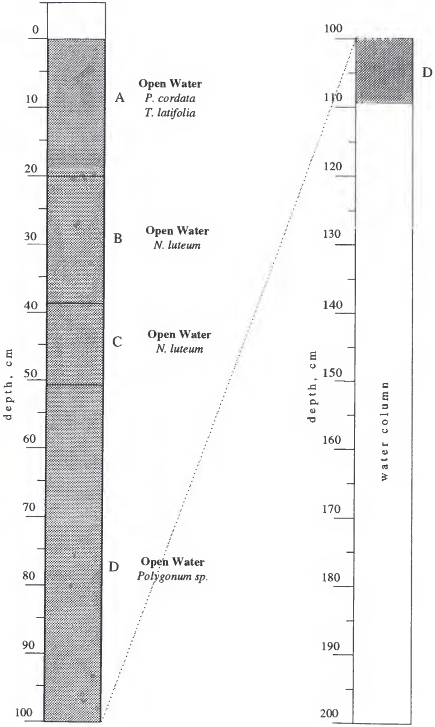


Figure D-4. Peat stratigraphy of floating island at site Fla-3A, organic base island flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

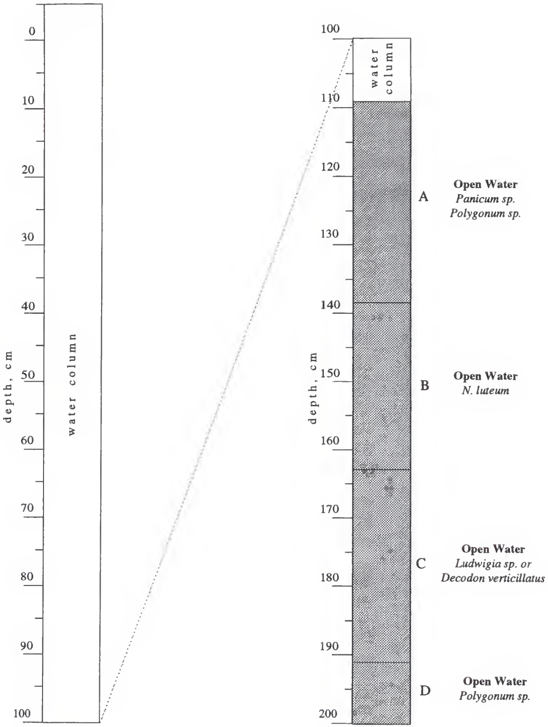


Figure D-5a. Peat stratigraphy of site FIb-1A, vegetative base island flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

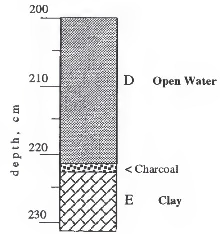


Figure D-5b. Peat stratigraphy of site FIb-1A, vegetative base island flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

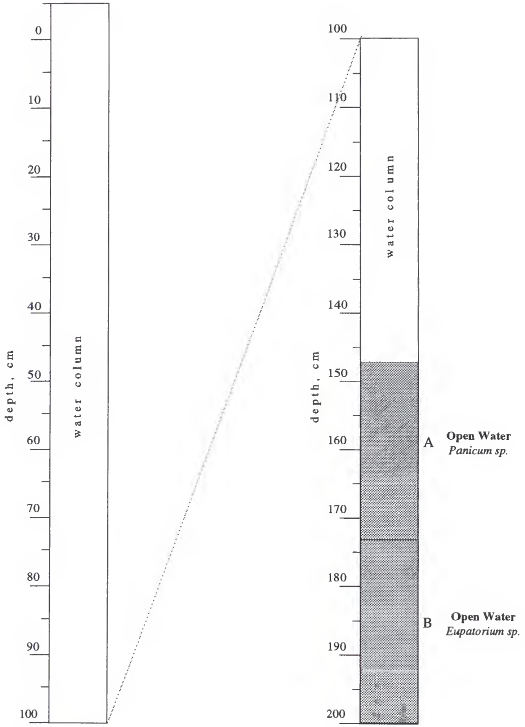


Figure D-6a. Peat stratigraphy of site FIb-3A, vegetative base island flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

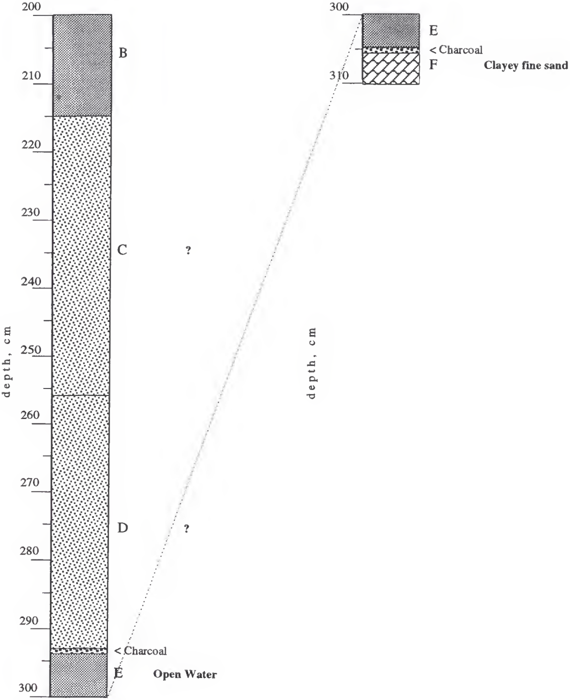


Figure D-6b. Peat stratigraphy of site FIb-3A, vegetative base island flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

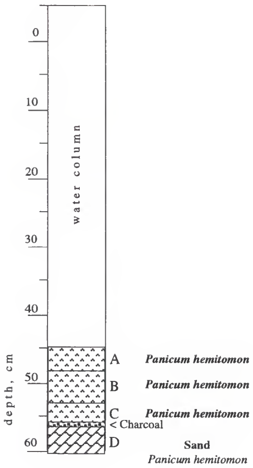


Figure D-7. Peat stratigraphy of site FMa(*P. hemitomon*)-1A, *Panicum* marsh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

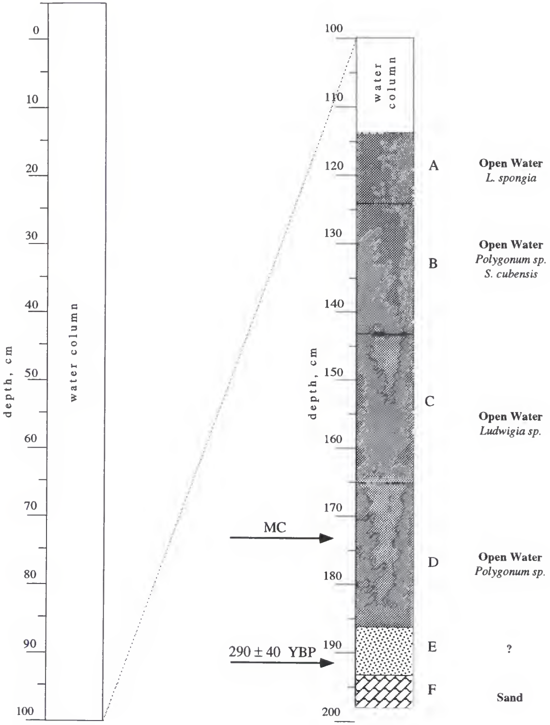


Figure D-8. Peat stratigraphy of site FMa(*S. cubensis*)-2A, floating bulrush marsh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

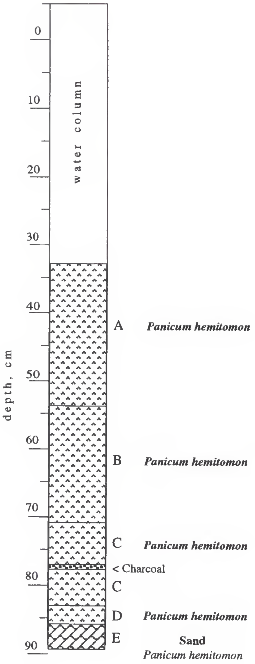


Figure D-9. Peat stratigraphy of site FMa(*P. hemitomon*)-3A, *Panicum* marsh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

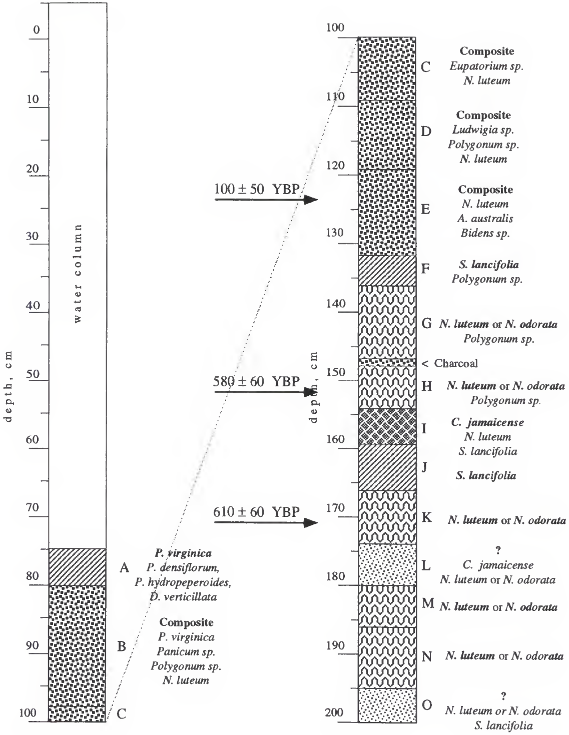


Figure D-10a. Peat stratigraphy of site FMb-1A, vegetative base floating marsh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

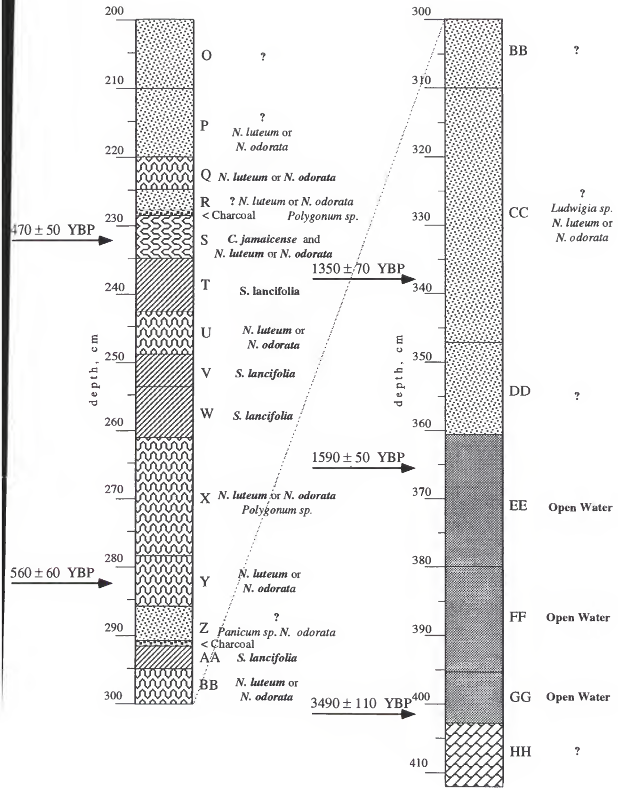

200
210
220
230
240
250
260
270
280
290
300
depth, cm
O ?
P ? N. luteum or N. odorata
Q N. luteum or N. odorata
R ? N. luteum or N. odorata
< Charcoal Polygonum sp.
70 ± 50 YBP
S C. jamaicense and N. luteum or N. odorata
T S. lancifolia
U N. luteum or N. odorata
V S. lancifolia
W S. lancifolia
X N. luteum or N. odorata Polygonum sp.
560 ± 60 YBP
Y N. luteum or N. odorata
Z ? Panicum sp. N. odorata
< Charcoal
AA S. lancifolia
BB N. luteum or N. odorata
1350 ± 70 YBP
1590 ± 50 YBP
3490 ± 110 YBP
300
310
320
330
340
350
360
370
380
390
400
410
depth, cm
BB ?
CC ? Ludwigia sp. N. luteum or N. odorata
DD ?
EE Open Water
FF Open Water
GG Open Water
HH ?

Figure D-10b. Peat stratigraphy of site FMb-1A, vegetative base floating marsh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

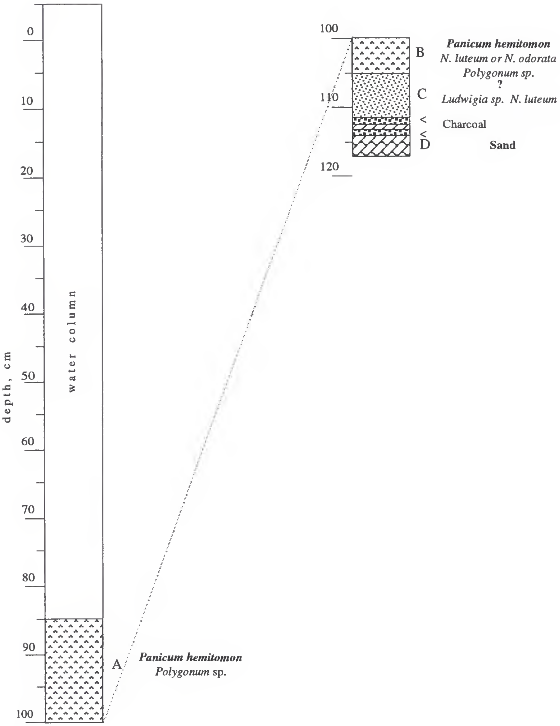


Figure D-11. Peat stratigraphy of site FMb-2A, vegetative base marsh flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

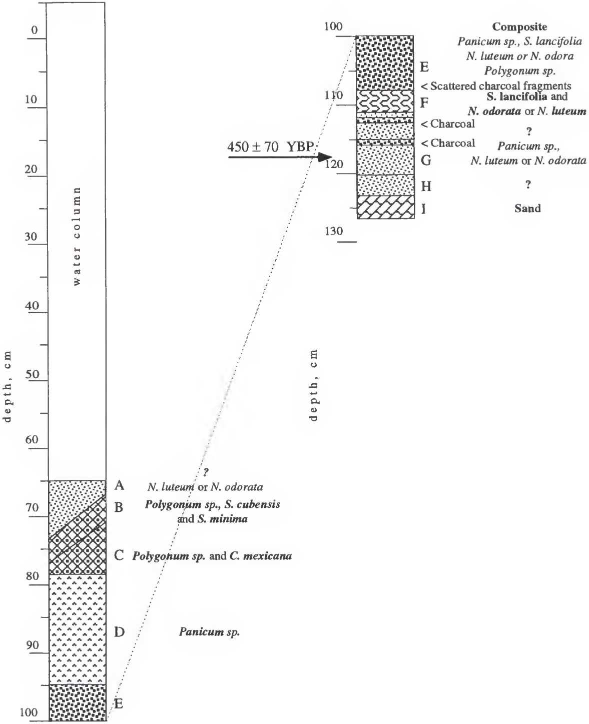

0
10
20
30
40
50
60
70
80
90
100
depth, cm
water column
A
N. luteum or N. odorata
B
Polygonum sp., S. cubensis and S. minima
C
Polygonum sp. and C. mexicana
D
Panicum sp.
E
?
450 ± 70 YBP
100
110
120
130
depth, cm
Composite
Panicum sp., S. lancifolia
N. luteum or N. odora
Polygonum sp.
E
< Scattered charcoal fragments
F
S. lancifolia and N. odorata or N. luteum
< Charcoal
?
< Charcoal
Panicum sp., N. luteum or N. odorata
G
H
?
I
Sand

Figure D-12. Peat stratigraphy of site FMb-3A, vegetative base marsh flotant Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment i n horizon. Species not in bold indicate other plant fragments identified in horizon.

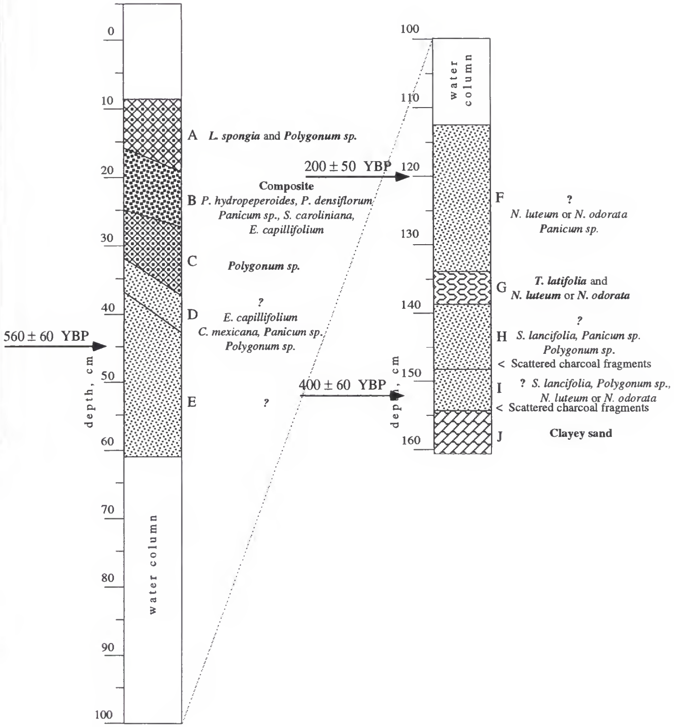

0
10
20
30
40
50
60
70
80
90
100
depth, cm
water column
560 ± 60 YBP
A L. spongia and Polygonum sp.
Composite
B P. hydropeperoides, P. densiflorum, Panicum sp., S. caroliniana, E. capillifolium
C Polygonum sp.
D ? E. capillifolium C. mexicana, Panicum sp., Polygonum sp.
E ?
200 ± 50 YBP
400 ± 60 YBP
100
110
120
130
140
150
160
water column
depth, cm
F ? N. luteum or N. odorata Panicum sp.
G T. latifolia and N. luteum or N. odorata
H ? S. lancifolia, Panicum sp. Polygonum sp.
< Scattered charcoal fragments
I ? S. lancifolia, Polygonum sp., N. luteum or N. odorata
< Scattered charcoal fragments
J Clayey sand

Figure D-13. Peat stratigraphy of site FMc-1A, organic base marsh flotant Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

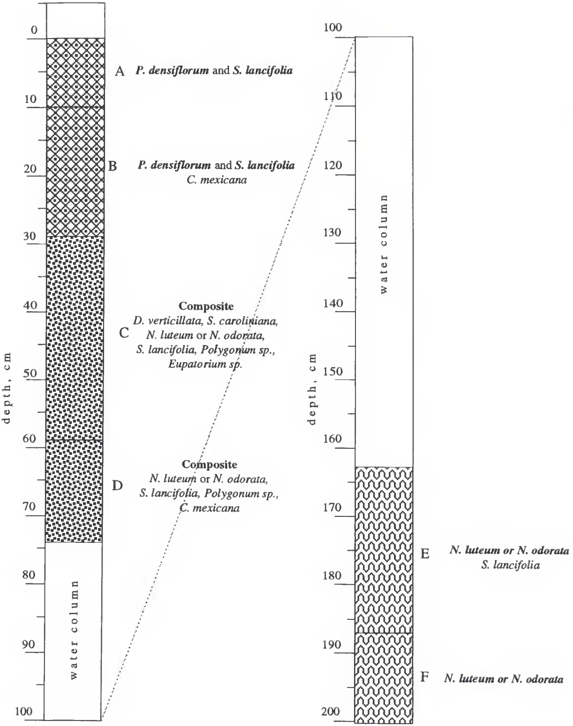

0
10
20
30
40
50
60
70
80
90
100
depth, cm
A P. densiflorum and S. lancifolia
B P. densiflorum and S. lancifolia
C. mexicana
Composite
C D. verticillata, S. caroliniana,
N. luteum or N. odorata,
S. lancifolia, Polygonum sp.,
Eupatorium sp.
Composite
D N. luteum or N. odorata,
S. lancifolia, Polygonum sp.,
C. mexicana
water column
100
110
120
130
140
150
160
170
180
190
200
depth, cm
water column
E N. luteum or N. odorata
S. lancifolia
F N. luteum or N. odorata

Figure D-14a. Peat stratigraphy of site FMc-2A. organic base marsh flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

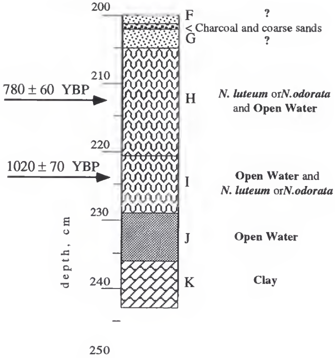


Figure D-14b. Peat stratigraphy of site FMc-2A, organic base marsh flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

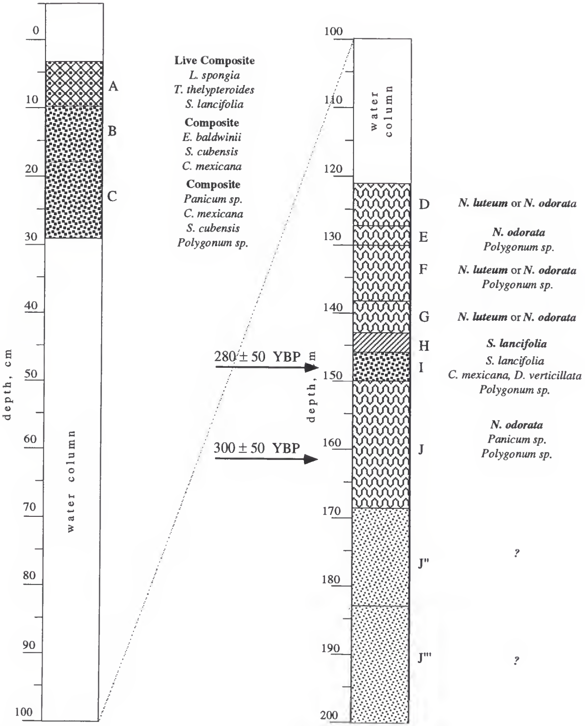


Figure D-15a Peat stratigraphy of site FMc-3A, organic base marsh flotant. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

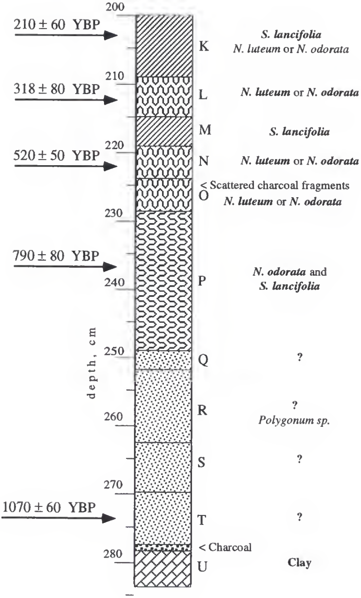


Figure D-15b. Peat stratigraphy of site FMc-3A, organic base marsh flotant . Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

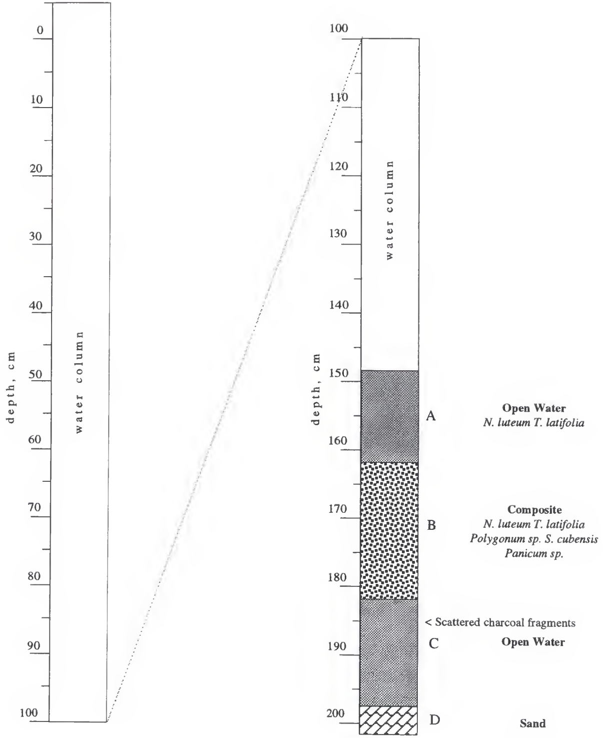


Figure D-16. Peat stratigraphy of site DMa-1A, deep marsh community. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

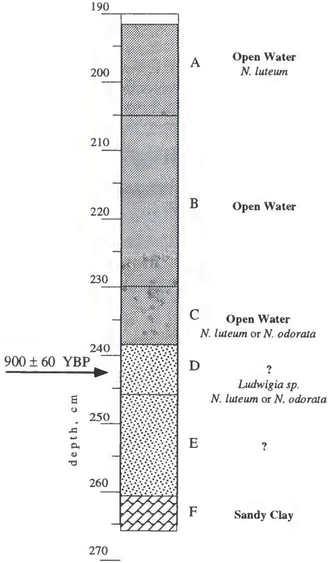


Figure D-17. Peat stratigraphy of site DMa-2A, deep marsh comunity. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

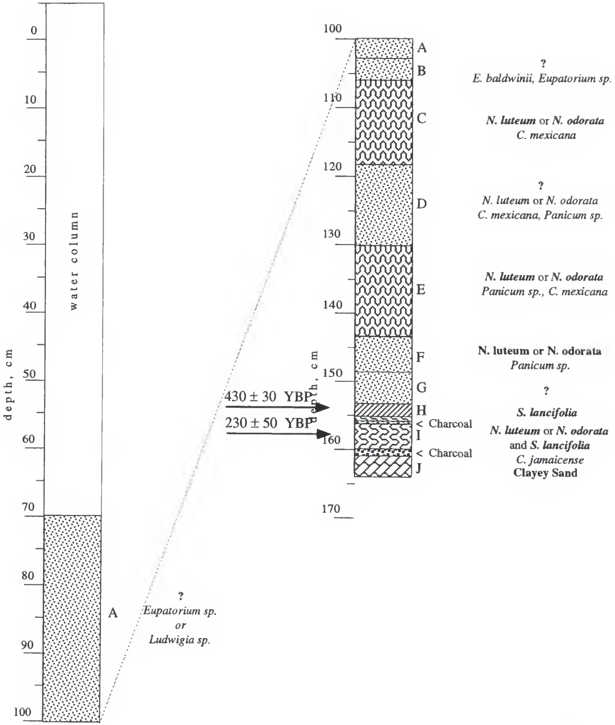


Figure D-18. Peat stratigraphy of site DMa-3A, deep marsh community. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

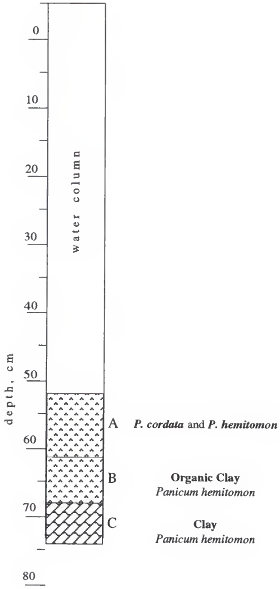


Figure D-19. Peat stratigraphy of site SMa-1A, broad-leaf marsh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

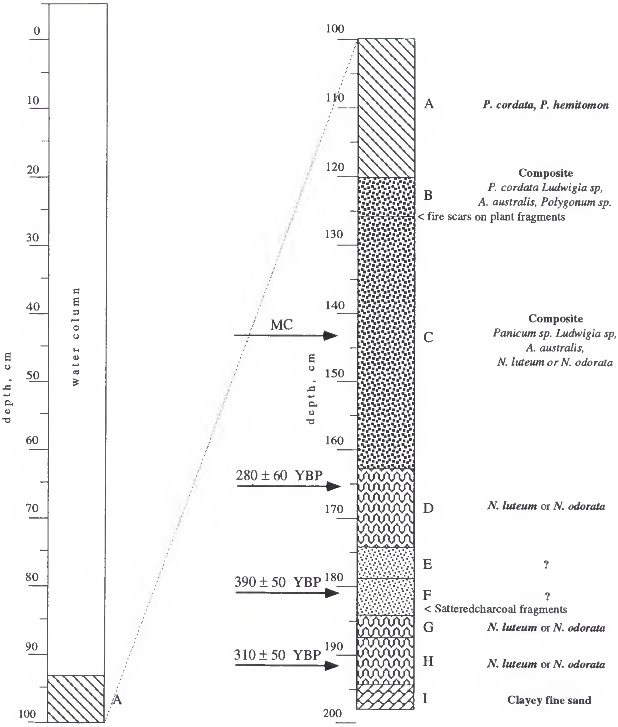

0
10
20
30
40
50
60
70
80
90
100
depth, cm
water column
A
100
110
120
130
140
150
160
170
180
190
200
depth, cm
MC
280 ± 60 YBP
390 ± 50 YBP
310 ± 50 YBP
A
P. cordata, P. hemitomon
B
Composite
P. cordata Ludwigia sp,
A. australis, Polygonum sp.
< fire scars on plant fragments
C
Composite
Panicum sp. Ludwigia sp,
A. australis,
N. luteum or N. odorata
D
N. luteum **or** ***N. odorata***
E
?
F
?
< Satteredcharcoal fragments
G
N. luteum **or** ***N. odorata***
H
N. luteum **or** ***N. odorata***
I
Clayey fine sand

Figure D-20. Peat stratigraphy of site SMa-2A, broad-leaf marsh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

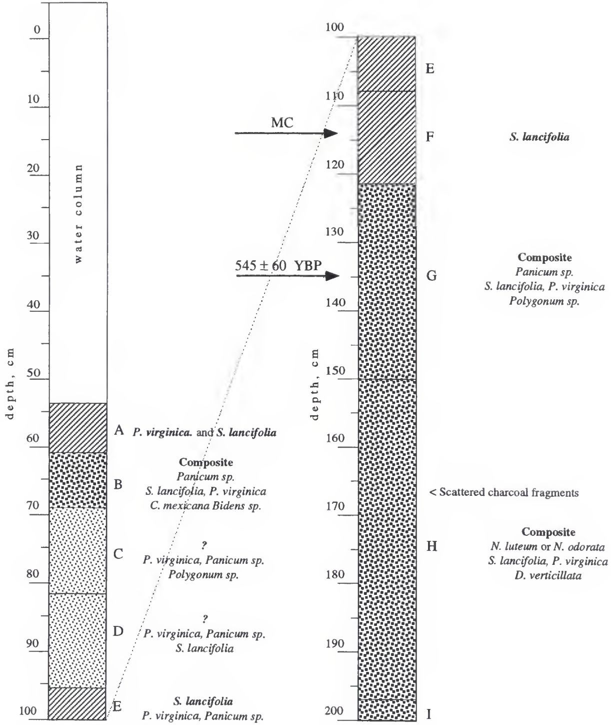


Figure D-21a. Peat stratigraphy of site SMa-3A, broad-leaf marh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

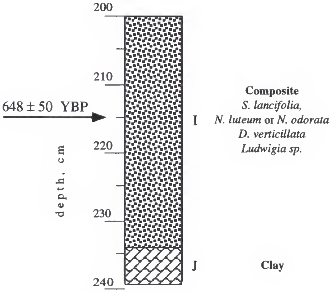


Figure D-21b. Peat stratigraphy of site SMa-3A, broad leaf marsh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

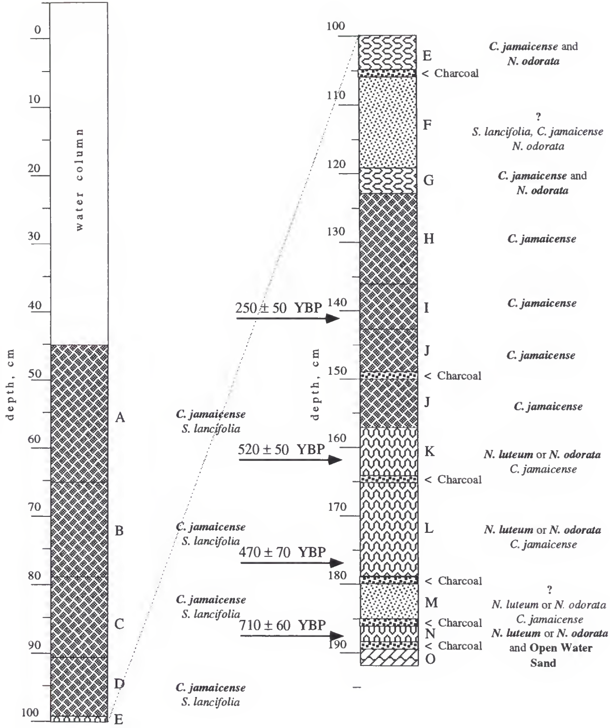


Figure D-22. Peat stratigraphy of site SMb-1A, linear-leaf marsh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

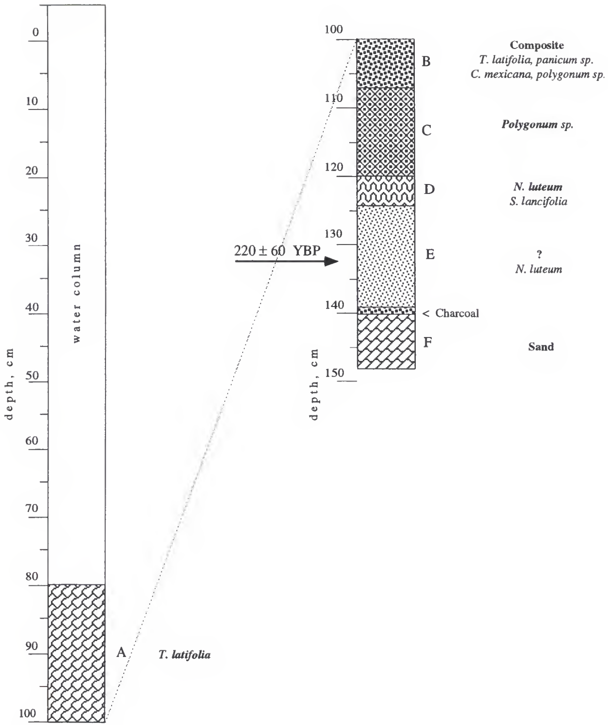


Figure D-23. Peat stratigraphy of site SMb-2A, linear-leaf marsh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

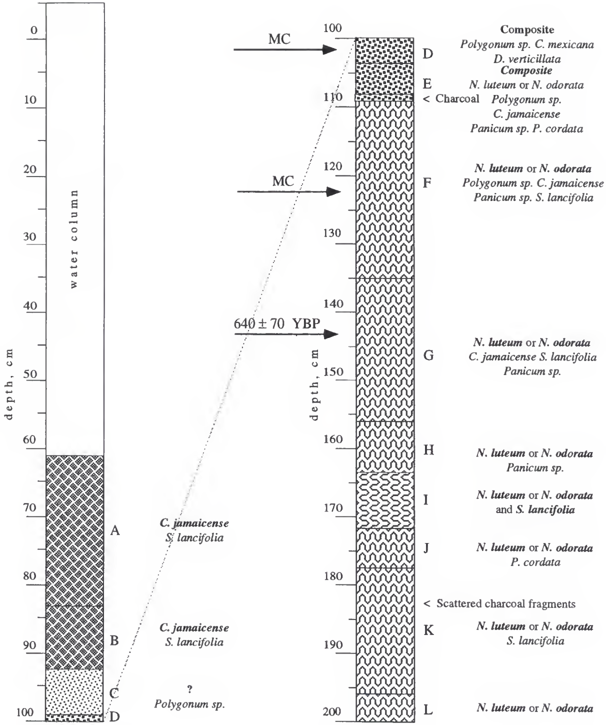


Figure D-24a. Peat stratigraphy of site SMb-3A, linear-leaf marsh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

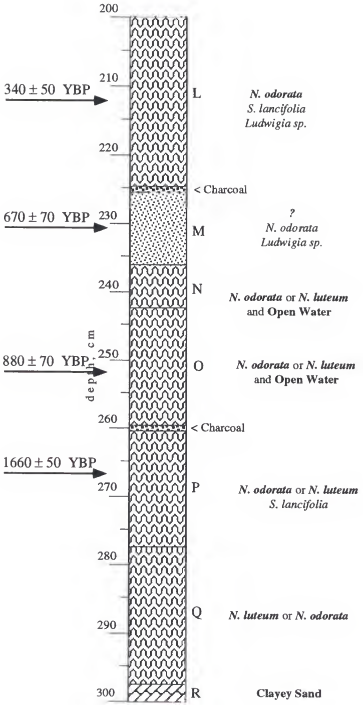


Figure D-24b. Peat stratigraphy of site SMb-3A, linear-leaf marsh. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

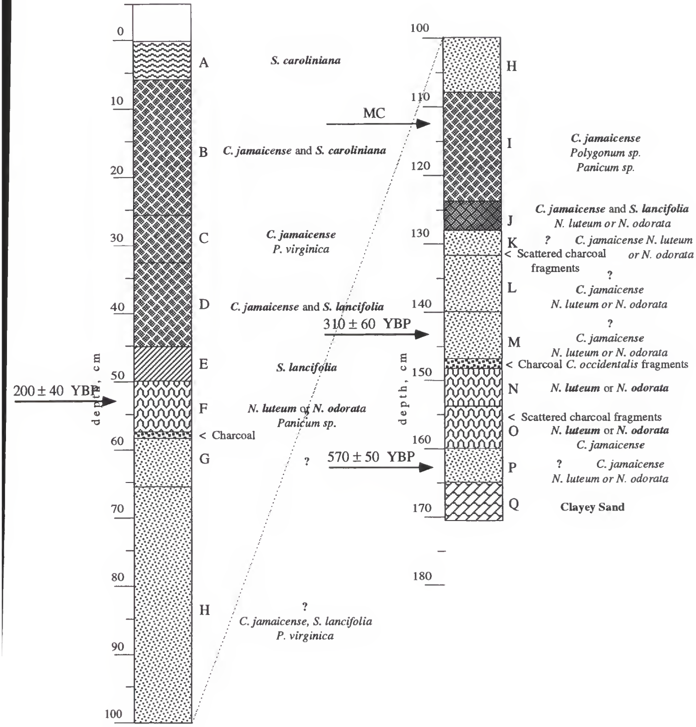


Figure D-25. Peat stratigraphy of site SSa-1A, shrub-scrub swamp community. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

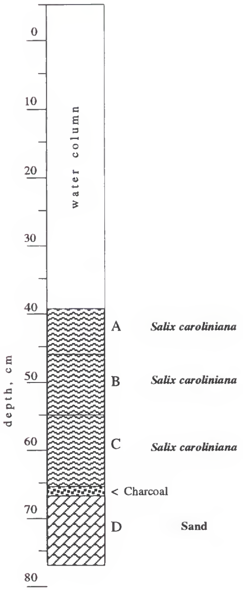


Figure D-26. Peat stratigraphy of site SSa-2A, scrub-shrub swamp community. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

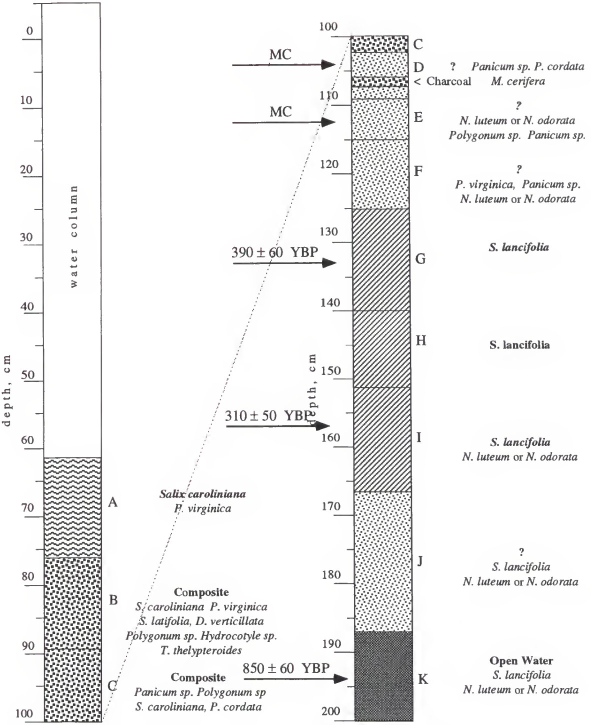


Figure D-27a. Peat stratigraphy of site SSa-3A, scrub-shrub swamp. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

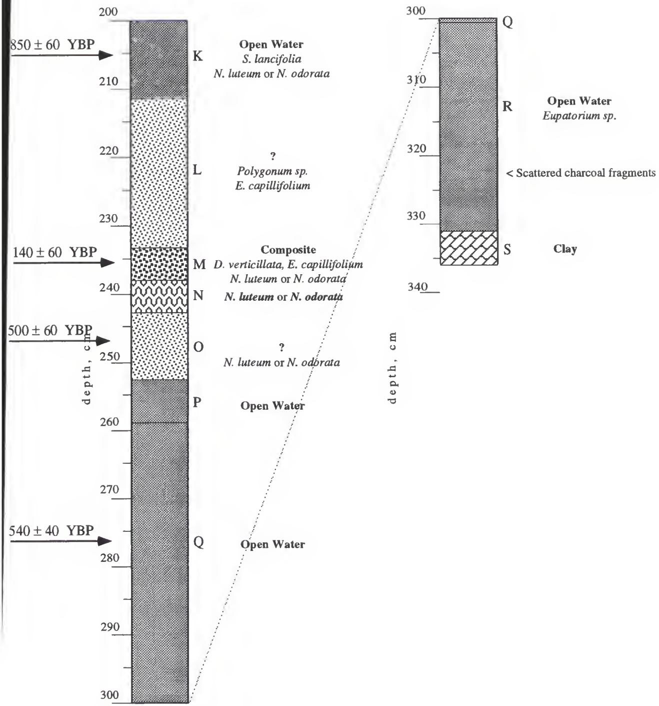


Figure D-27b. Peat stratigraphy of site SSa-3A, scrub- shrub swamp. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

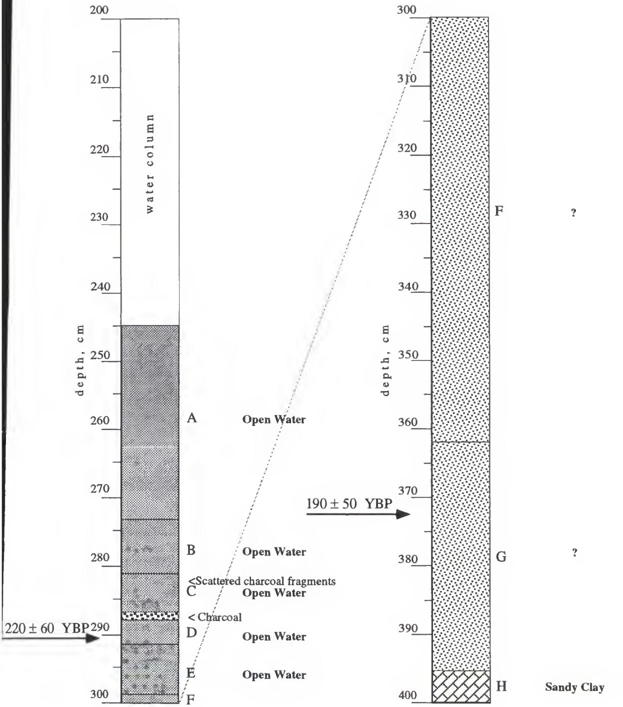


Figure D -28. Peat stratigraphy of site OWa-1B, open water comunity. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

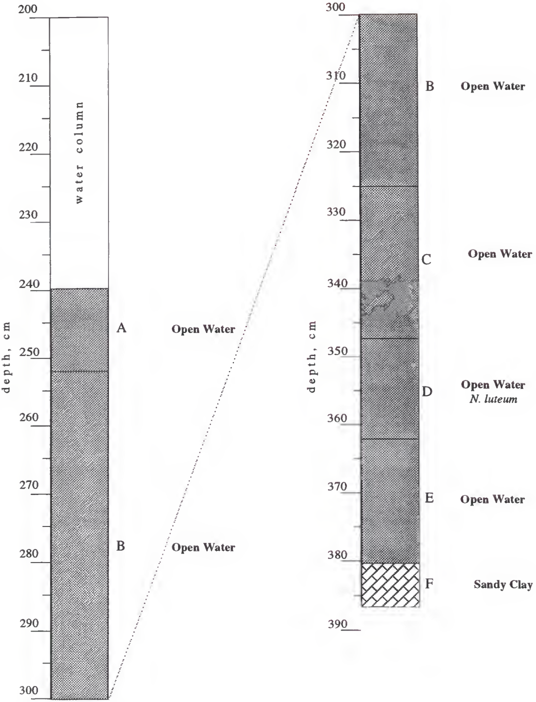


Figure D-29. Peat stratigraphy of site OWa-2A, open water comunity. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

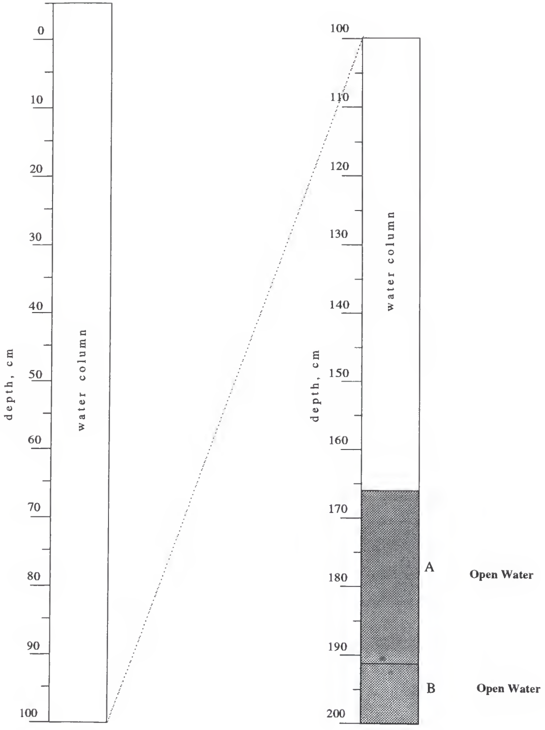


Figure D-30a. Peat stratigraphy of site OWa-3B, open water community. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon. .

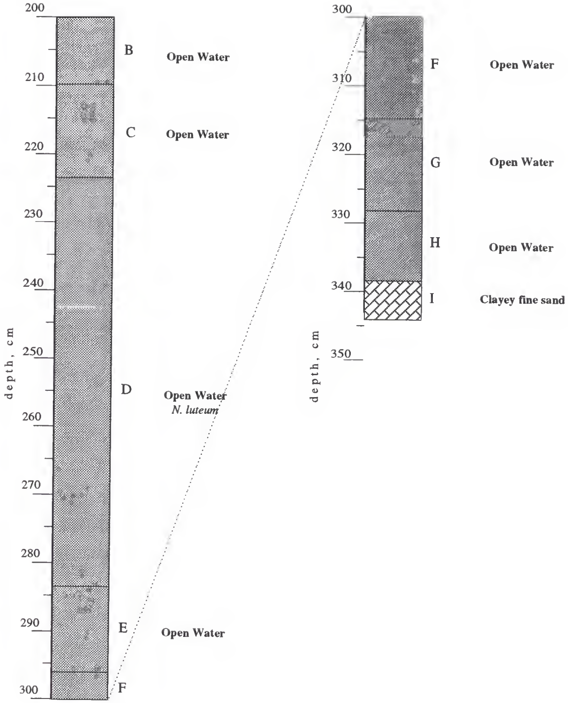


Figure D-30b. Peat stratigraphy of site OWa-3B, open water comunity. Letter designates core horizon. Bold print indicates most probable species or community contributing to sediment in horizon. Species not in bold indicate other plant fragments identified in horizon.

Notes for Horizon Characterization and plant fragment identification tables.

Composition

Composition of sediments were described using one of the following five descriptors.

litter:	Easily identified plant fragments with little or no decomposition throughout horizon
mineral:	Greater than 50% by volume is composed of mineral sediments
sapric:	Organic sediment in which 30% or less by volume of original plant parts are recognizable by the unaided eye.
hemic:	Organic sediment in which greater than 30%, but less than 70 %, of the horizon is recognizable as original plant parts.
fibric:	Organic sediment in which greater than 30% of the sediment can be recognized as plant parts.

Texture

Texture of horizons was classified as at least one of the following 11 categories

fine:	no identifiable particles when rubbed between fingers
firm:	offers moderate resistance when squeezed between fingers
coarse:	recognizable particles when rubbed between fingers unless identified by other terms
crumbly:	broke apart into smaller chunks when placed in palm of hand
plastic:	sample formed a ribbon when pressed through fingers (clay)
pasty:	sample sticks to fingers more readily then coheres onto itself
sinuous:	long stringy fibers

blocky: fracture zones roughly equal along vertical and horizontal axis forming blocks or chunks within horizon

platy: fractures with length along the horizontally axis noticeably greater than along the vertical axis.

granular: noticeable aggregates of firmer organic substrate up to 1 cm in size. Aggregates larger than 1 cm fall under blocky or platy categories.

grainy: presence of sand in substrate when rubbed between fingers.

Structure Code

Structure of the horizon was determined 5 minutes after the core was extracted from the liner and prior to the core being cut in half. The index of structure was based on a horizons characteristic slumping and connectivity under a horizontal gravitational force while in the trough. The categories were defined based on distinguishable characteristics of horizons and are identified using a number code as follows;

1 Sediment material which settles below the water surface pooled in the trough.

2 Sediment material which settles equal to the water surface in the trough.

3 Sediment or plant material which settles slightly above the water surface.

4 Sediment which subsides more than 75% of round and easily breaks under its own weight along the edge of the trough.

5 Sediment with a medium subsidence < 50% of round and has only minor breakage along the edge of the trough under its own weight.

6 Sediment which subsides only slightly < 25% of round and does not break along edge.

7 Sediment that does not subside and is primarily of a sapric or hemic composition.

8 Sediment that does not subside and is primarily of a filamentous composition.
9 Containing aggregates of a filamentous nature.
10 Containing aggregates of a fine textured composition.

Boundary Code

Boundary codes characterize the lower boundary interface of a horizon. The categories are numerical and defined as follows;

1 No clear boundary, more of a gradual transition.
2 No clear boundary, but can be resolved to within 2 cm.
3 Easily identified boundary, but is wavy or not perpendicular to the orientation of the core.
4 Easily detected and can be resolved to within a .5 cm zone
5 Easily detected to less than 0.5 cm often resulting from a change in parent material or clear change in horizon color.

Horizon characterization and plant fragment identification of sediment core sampled at site Fla-1A, Floating Island Community Type Fla. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	0-4	7.5yr 2.5/2	sapric	fine	6	2	*H. umbellata* *N. luteum*	Open Water *N. luteum* *Ludwigia sp.*		fine sapric sediment, live roots and stolon of *H. umbellata* and *N. luteum*, *Ludwigia* sp. seeds at base of horizon.
B	4-29	7.5yr 2.5/2	sapric	fine	5	3	*N. luteum*	Open Water *N. luteum*		fine unconsolidated sapric sediment, live and dead *N. luteum*, rhizome and anchor roots
open water	29-146									
C	146-150	7.5yr 2.5/2	hemic	fine	8	5		*Panicum sp.*		fibric horizon composed of roots and stolon of *Panicum* sp.
D	150-	7.5yr 4/1	mineral	grainy	7					uncoated sands

Horizon characterization and plant fragment identification of sediment core sampled at site FIa-2A, Floating Island Community Type FIa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A'	-6-0	7.5yr 2.5/2	sapric	fine	7	4	*H. umbellata*	Open Water		consolidated and dryer sapric sediment, numerous rootlets of *H. umbellata*
A"	0-26	7.5yr 2.5/2	sapric	fine	5	2	*N. luteum*	Open Water *N. luteum*		*N. luteum* rhizomes and roots, less consolidated sapric sediments then in above horizon
B	26-43	7.5yr 2.5/2	sapric	fine	6	2		Open Water *N. luteum*		more consolidated, slight increase the number of fragments
C	43-68	7.5yr 2.5/2	hemic	fine	7	1		*N. luteum*		firmer hemic sediment, several large woody fragments, appear to be *Quercus* sp., root of *N. luteum*
open water	68-210									
D	210-310	7.5yr 2.5/2	sapric	fine	4	2		Open Water	scattered charcoal	loose floculant, plant fragments accumulated in bottom of horizon, firm aggregates of hemic material with centroid darker then surrounding horizon, scattered charcoal fragments
E	310-333	7.5yr 2.5/2	hemic	blocky	5	5		Open Water	scattered charcoal	increase in consolidation and number of plant fragments, scattered charcoal throughout horizon
F	333-342	7.5yr 2.5/N	clay	pasty	7				large and small fragments laying above mineral	silty clay mineral horizon overlaid with small and large fragments of charcoal.

Horizon characterization and plant fragment identification of sediment core sampled at site FIa-2B, Floating Island Community Type FIa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A'	-3-0	7.5yr 2.5/2	sapric	fine	6	3	*Bidens laevis* *S. cubensis* *P. cordata* *P. hemitomon*	Open Water		roots and stolons of *B. laevis*, *S. cubensis*, *P. cordata* and *P. hemitomon*, leaf and stem of *P. cordata*, fine sapric sediment consolidated and slightly drier then horizon below
A"	0-11	7.5yr 2.5/2	sapric	fine	5	1	*N. luteum* *P. cordata*	Open Water *N. luteum*		fine sapric sediment, less consolidated then above, *N. luteum* rhizome, root and rootlet
B	11-32	7.5yr 2.5/2	sapric	fine	4	4	*N. luteum*	Open Water *T. latifolia* *Ludwigia sp. or Eupatorium sp.*		fine sapric sediment less consolidated then horizon above, fragments of *Ludwigia* sp. or *Eupatorium* sp. and *T. latifolia.*
open water	32-285									
C	285-342	7.5yr 2.5/2	sapric	fine flocculant blocky	5, 10	2		Open Water		loose fine flocculant sapric sediment, few plant fragments, soft blocky aggregates of sapric sediment suspended in more floculant sediment.
D	342-358	7.5yr 2.5/2	sapric	fine blocky	6, 10	3		Open Water		more consolidated, large firm organic aggregates similar to ones found in F horizon, unidentified plant fragments
E	358-366	7.5yr 2.5/2	sapric	fine platy	7, 10	4		Open Water		firm plats of organic aggregates composed of fine textured sapric sediment, dead roots between layers.
F	366-	7.5yr 2.5/2	mineral	grainy	7					clayey fine sands

Horizon characterization and plant fragment identification of sediment core sampled at site FIa-3A, Floating Island Community Type FIa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	8-20	7.5yr 2.5/1	sapric	fine	4	5	*P. cordata*	Open Water *P. cordata* *T. latifolia*		fine consolidated sapric sediment, live *P. cordata* roots, fragments of *T. latifolia* in bottom of horizon, well preserved or young fragments found in bottom of horizon
B	20-39	7.5yr 2.5/2	sapric	fine	6	2	*N. luteum*	Open Water *N. luteum*		more consolidated then above, large pocket of *N. luteum* roots also seeds of *N. luteum,* live rhizom of *N. luteum* identified in buoyancy cores
C	39-52	7.5yr 2.5/2	sapric	fine	5	3		Open Water *N. luteum*		less consolidated then above, small plant fragments unk, *N. luteum* seeds
D	52-108	7.5yr 2.5/2	sapric	fine	6	5		Open Water *Polygonum sp.*		firmer fine sediment, small organic accretions, large fragment of *Polygonum* sp., seeds of unknown plant.

Horizon characterization and plant fragment identification of sediment core sampled at site FMc-1A, Floating Marsh Community Type FMc. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	9-16/19		litter		3	3	*L. spongia* *Polygonum sp.*			mix of stems, roots and rhizomes of vegetation identified in plot some loose floculant sediment associated with root mat but minimal
B	16/19-25/27	7.5yr 3/3	fibric	coarse	6	4	*L. spongia*	*P. hydropeperoides, P. densiflorum, Panicum sp., S. caroliniana, E. capillifolium*		dense network of rootlets primarily that of L. spongia, and very coarse partially decomposed plant fragments.
C	25/27-32/37	7.5yr 2.5/2	fibric	coarse	6	4	*L. spongia*	*Polygonum sp.*		numerous partially decomposed plant fragments mostly of *Polygonum* sp. little or no decomposed organic material
D	32/37-37/43	10yr 2/2	fibric	coarse	4	5	*L. spongia*	*E. capillifolium, C. mexicana, Panicum sp., Polygonum sp.*		upper part of horizon consisting of numerous plant fragments with little or no decomposed organic, bottom of horizon is primarily water with roots of *L. spongia* bridging the open-water and connecting to horizon E below.
E	37/43-61	7.5yr 2.5-2	fibric	coarse	8	5		?		mostly crumbly peat of small plant fragments, peaty aggregates of 5-7 cm in diameter.
open water	61-113									
F	113-134	7.5yr 2.5/1	hemic	crumbly	6	4		? *N. luteum or N. odorata, Panicum sp.*		loose crumbly, with peaty block in upper and lower portions of horizon
G	134-138	7.5yr 2.5/3	fibric	fine	8	4		*N. luteum or N. odorata, T. latifolia*		rhizome of *Nuphar lutem* and in fine textured fibric peat
H	138-148	7.5yr 2.5/2 7.5yr 4/6	hemic	fine	8	3		? *S. lancifolia, Panicum sp., Polygonum sp.*	scattered fragments	Fine textured hemic peat with band of light tan peat of *Sagittaria lancifolia* below layer *of S. lancifolia* + mix including *Polygonum* sp.
I	148-155	7.5yr 2.5/1	hemic	fine	8	5		? *S. lancifolia, Polygonum sp., N. luteum or N. odorata*	scattered fragments	scattered charcoal fragments in borderline hemic fibric composition.
J	155-	7.5yr 2.5/N	mineral	plastic grainy	8					Clayey sand

Horizon characterization and plant fragment identification of sediment core sampled at site FMc-2A, Floating Marsh Community Type FMc. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	0-10		litter		1	2	*L. spongia* *S. lancifolia* *T. thelypteroides*	*P. densiflorum* *S. lancifolia*		some loose sapric sediment, numerous roots, stems and leaves of *L. spongia*, *S. lancifolia* and *T. thelypteroides*
B	10-29	7.5yr 2.5/2	hemic	coarse	3	3	*S. lancifolia*	*P. densiflorum*, *S. lancifolia*, *C. mexicana.*		little or no organic sediment, liver and dead roots of *S. lancifolia*, plant fragments of *Polygonum* sp.
C	29-59	5yr 2.5/2	fibric	coarse	8	4	*S. lancifolia*	*D. verticillata*, *S. caroliniana*, *N. luteum or N. odorata*, *S. lancifolia*, *Polygonum sp. Eupatorium sp.*		fibric sediment, live and dead roots of *S. lancifolia* throughout horizon, fragments of *Polygonum* sp. and *Eupatorium* sp.
D	59-74	7.5yr 2.5/2	hemic	fine	8	3	*S. lancifolia*	*N. luteum or N. odorata*, *S. lancifolia*, *Polygonum sp.*, *C. mexicana*		fine firm hemic sediment, live and dead roots of *S. lancifolia* roots
open water										
E	163-187	7.5yr 2.5/2	fibric	coarse	8	4		*N. luteum or N. odorata*, *S. lancifolia*		firm consolidated fibric sediment, dead roots of *S. lancifolia*
F	187-201	7.5yr 2.5/2	fibric	coarse crumbly	8	5		*N. lutuem or N. odorata*		loose crumbly hemic sediment
G	201-205	7.5yr 2.5/3	fibric	sinuous	8	4		*?*	top of horizon has fragments and coarse sands	dense fibric sediment, *N. luteum* rhizome, upper horizon has charcoal fragments and scattered coarse sands.
H	205-221	7.5yr 2.5/2	hemic	fine	8	3		*N. luteum or N. odorata*, Open Water		less consolidated hemic sediment,
I	221-229	7.5yr 2.5/2	sapric	fine floculant	6	3		*N. luteum or N. odorata*, Open Water		loose floculant fine sapric sediment, no plant fragments
J	229-236	7.5yr 2/52	hemic	fibric blocky	8	3		Open Water		dense hemic sediment, blocky fracture pattern, roots of unknown species between blocks
K	236-	7.5yr 2.5/1	mineral	plastic	8					clay silt with sapric organic intermixed

Horizon characterization and plant fragment identification of sediment core sampled at site FMc-3A, Floating Marsh Community Type FMc. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	4-10		litter	coarse	6	3	*L. spongia* *T. thelypteroides* *S. lancifolia*			root mat of predominantly *Thelypteris thelypteroides*, little or no organic sediment
B	10-18		fibric	coarse	4	4		*E. baldwinii,* *S. cubensis,* *C. mexicana*		partially decomposed roots and shoots of *E. baldwinii* and *E. baldwinii*, some loose floculant
C	18-29	10yr 2/2	hemic	coarse crumbly	8	5		*Panicum sp.,* *C. mexicana,* *S. cubensis,* *Polygonum sp.*		hemic sediment with fragments of Cicuta mexicana and *Panicum* sp., other plant fragments unidentified.
open water										
D	121-127	7.5yr 2.5/2	hemic	fine	8	3		*N. luteum or* *N. odorata*		fine hemic sediment with fine roots hairs and rhizome of *N. luteum* or *N. odorata*
E	127-130	7.5yr 2.5/3	hemic	fine	8	3		*N. luteum or* *N. odorata* *Polygonum sp.*		only plant fragments identified at macro level were *Polygonum* sp., distinct break at bottom of horizon
F	130-138	7.5yr 2.5/2	hemic	fine	8	4		*N. luteum or* *N. odorata,* *Polygonum sp.*		*N. luteum* or *N. odorata* rhizome fragments, *Panicum* sp. stolon, fine hemic sediment
G	138-143	7.5yr 2.5/2	fibric	coarse	8	4		*N. luteum or* *N. odorata*		*N. luteum* or *N. odorata* plant fragments in fibric sediment
H	143-146	7.5yr 2.5/3	fibric	coarse	8	3		*S. lancifolia*		*S. lancifolia* rhizome in fibric sediment
I	146-150	10yr 2/2 7.5yr 4/4	fibric	coarse	8	4		*S. lancifolia,* *C. mexicana,* *D. verticillata,* *Polygonum sp.*		clum base of *S. lancifolia*, *Panicum* sp. stolon, firm fibric sediment
J'	150-168	5yr 2.5/2	fibric	fine dense	8	4		*N. luteum or N. odorata, Panicum sp.* *Polygonum sp.*		fine very dense fibric sediment short fiber length, fragments of *Panicum* sp. *Polygonum* sp.
J"	168-183	5yr 2.5/2	fibric	fine	8	3		*?*		wavy horizon of light and dark fibric sediment, patches of yellow powder like pollen or early seed.
J'"	183-200	7.5yr 2.5/3	fibric	fine	8	4		*?*		fine fibric peat
K	200-208	7.5yr 2.5/2 7.5yr 3/3	fibric	coarse	8	4		*N. luteum or* *N. odorata* *S. lancifolia*		dark and light bands of peat alternating, dark bands *N. luteum or N. odorata*, light bands *S. lancifolia*
L	208-215	7.5yr 2.5/3	fibric	fine	8	4		*N. luteum or* *N. odorata*		fine fibric peat, fragments of *N. odorata or N. luteum* similar to J'" horizon
M	215-219	7.5yr 4/4	fibric	coarse	8	4		*S. lancifolia*		coarse fibric peat, light brown color, *S. lancifolia* plant fragments

Core sampled at site FMc-3A, continued.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
N	219-224	5yr 2.5/2	fibric	coarse	8	4		*N. luteum or N. odorata*		woody fragments at top of horizon with *N. odorata* or *N. luteum* fragments coarse fibric
O	224-228	7.5yr 2.5/2	hemic	fine	8	5		*N. luteum or N. odorata*		clear break at bottom of horizon, light and dark banding of horizon
P	228-249	7.5yr 2.5/2	hemic	fine	8	4		*N. luteum or N. odorata* *S. lancifolia*	scattered fragments	vertical root channels in horizon probably *N. luteum* or *N. odorata*, scattered charcoal throughout
Q	249/251-251/252	7.5yr 2.5/3	fibric	sinuous	8	5		?		fine rootlets of unknown species, no organic component, reddish tan coloration
R	251/252-263	7.5yr 2.5/1	hemic	fine	8	3		? *Polygonum sp.*		fine hemic peat fragments unknown
S	263-270	7.5yr 2.5/2	hemic	fine	6	3		?		consolidated floculant, stringy and spongy
T	270-277	7.5yr 2.5/1	hemic	fine	6	4		?		fine hemic sediments, no fragments identified
U	277-284	7.5yr 2.5/N	mineral	clay	7				fragments on surface of horizon	silty clay, a lot of charcoal at surface of mineral horizon

Horizon characterization and plant fragment identification of sediment core sampled at site FIb-1A, Floating Island Community Type FIb. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	109-138	7.5yr 2.5/2	sapric	fine	3	1		Open Water *Panicum sp.* *Polygonum sp.*		floculant, blocky aggregates of firm peat suspended at bottom of horizon, also fragments of *Panicum sp.* and *Polygonum sp.*
B	138-163	7.5yr 2.5/2	sapric	fine	4	2		Open Water *N. luteum*		more consolidated sapric sediments with small fragments of *N. luteum* rhizome and other unidentified fragments.
C	163-192	7.5yr 2.5/2	sapric	granular	6	4		Open Water *Ludwigia sp. or D. verticillatus*		organic granular texture, several larger fragments of woody herbaceous.
D	192-221	7.5yr 2.5/2	hemic	platy	7	4		Open Water *Polygonum sp.*		consolidated hemic sediment, platy separation
E	221-232	7.5yr 2.5/2 7.5yr 6/1	mineral	plastic	7				small fragments layered at clay pickup	dense clay/organic sediment charcoal fragments interspersed with concentration correlated with pick-up in clay content, pockets of light gray appears to be ash.

Horizon characterization and plant fragment identification of sediment core sampled at site FIb-3A, Floating Island Community Type FIb. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	147-173	7.5yr 2.5/2	sapric	fine	4	1		Open Water *Panicum sp.*		loose flocculant, several large fragments of *Panicum* sp., small unidentified fragments
B	173-215	7.5yr 2.5/2	sapric	fine	4	1		Open Water *Eupatorium sp.*		more consolidated then above, fine sapric sediment, 2 large stumps of *Eupatorium sp.*, other unidentified fragments
C	215-256	7.5yr 2.5/2	hemic	fine	6	1		?		fine hemic sediment no large fragments, more consolidated
D	256-293	7.5yr 2.5/2	hemic	fine	6	5		?		small unidentified plant fragments, fine sapric sediment,
E	293-305	7.5yr 2.5/2	sapric	fine	6	5		Open Water	fragment layer at top of horizon	layer of charcoal fragments at top of horizon, less consolidated then horizon above, fine sapric sediment
F	305-310	10yr 2/N	mineral	plastic gritty	7				fragments at top of horizon	clayey sand mineral sediment, layer of charcoal fragments between organic sediment interface.

Horizon characterization and plant fragment identification of sediment core sampled at site FMb-1A, Floating Marsh Community Type FMb. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth (cm)	Color (Munsell)	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	75-80	7.5yr 2.5/2	hemic	coarse	6	3	*P. virginica*	*P. virginica, P. densiflorum, P. hydropeperoides, D. verticillata*		loose organic with numerous live roots and rootlets of *Peltandra virginica* throughout
B	80-97	7.5yr 2.5/2	hemic	coarse	6	3	*P. virginica*	*P. virginica, Panicum sp., Polygonum sp., N. luteum*		similar consistency to A horizon but with less number of roots and no rootlets
C	97-109	7.5yr 2.5/2	hemic	fine	8	4	*P. virginica*	*Eupatorium sp., N. luteum*		more consolidated hemic then horizon B, some woody fragments possible *Eupatorium sp.*
D	109-119	7.5yr 2.5/2	hemic	coarse	8	3		*Ludwigia sp., Polygonum sp., N. luteum*		coarse texture with loose organic sediment, numerous plant fragment with distinct break in horizon at 110 cm
E	119-132	7.5yr 2.5/2	fibric	fine	8	3		*N. luteum, A. australis, Bidens sp.*		more consolidated fibric sediment then horizon D, large plant fragments at top of horizon.
F	132-136	7.5yr 5/6	fibric	coarse	8	4		*S. lancifolia, Polygonum sp.*		light tan horizon with rhizome and shoots of *S. lancifolia* or *P. virginica*
G	136-147	7.5yr 2.5/3	fibric	fine	8	4		*N. luteum or N. odorata, Polygonum sp.*		fine textured peat, dead roots of *Peltandra virginica*
H	147-154	7.5yr 2.5/2	fibric	fine	8	4		*N. luteum or N. odorata, Polygonum sp.*	band at top of horizon	charcoal band at top of horizon 147 cm overlying compact fine peat
I	154-159	7.5yr 2.5/3	fibric	coarse	8	4		*C. jamaicense, N. luteum or N. odorata, S. lancifolia*		coarse fibric sediment with deep reddish brown coloration, most likely C. jamaicense
J	159-166	7.5yr 5/8	fibric	fine	8	5		*S. lancifolia*		distinct break at bottom of horizon
K	166-174	7.5yr 2.5/2	fibric	fine	8	5		*N. luteum or N. odorata*		less consolidated horizon then above, fibric
L	174-180	7.5yr 2.5/2	fibric	fine, firm	8	4		*?* *C. jamaicense, N. luteum* or *N. odorata*		firmer consistency then M horizon firm peat
M	180-186	7.5yr 2.5/3	fibric	coarser	8	4		*N. luteum or N. odorata*		coarser peat with *N. luteum* or *N. odorata* rhizome fragments
N	186-195	7.5yr 2.5/2	fibric	fine, firm	8	4		*N. luteum or N. odorata*		fine texture peat firmer then horizon above
O	195-210	7.5yr 2.5/3	fibric	fine	8	4		*?* *N. luteum or N. odorata, S. lancifolia*		reddish brown peat of fine texture light vertical band of lighter peat penetrating horizon from top

Core sampled at site FMb-1A, continued.

P	210-220	7.5yr 2.5/2	fibric	fine	8	4		? *N. luteum or N. odorata*		fibric sediment firmer then horizon above
Q	220-225	7.5yr 2.5/2	fibric	fine coarse	8	4		*N. luteum or N. odorata*		light and darker horizontal bands within the horizon.
R	225-228	7.5yr 2.5/2	fibric	fine	8	4		? *N. luteum or N. odorata, Polygonum sp.*	band at bottom of horizon	clear break at bottom of horizon with charcoal layer at bottom
S	228-235	7.5yr 2.5/2	fibric	coarse	8	4		*C. jamaicense, N. luteum or N. odorata*		coarser textured peat with large plant fragments in center of horizon.
T	235-243	7.5yr 2.5/3	fibric	coarse	8	4		*S. lancifolia*		coarse peat with light band near top of horizon
U	243-248	7.5yr 2.5/3	fibric	fine	8,9	4		*N. luteum or N. odorata*		fine peat , hemic nodules 2-3cm in diameter throughout horizon
V	248-254	7.5yr 5/8	fibric	coarse	8	4		*S. lancifolia*		light colored horizon with fibrous peat of *S. lancifolia* or *P. virginica*
W	254-261	7.5yr 2.5/2	fibric	fine	8	4		*S. lancifolia*		firm fine textured peat of reddish brown color.
X	261-278	7.5yr 2.5/1	fibric	fine	8	4		*N. luteum or N. odorata, Polygonum sp.*		similar to horizon above with slightly darker brown chroma
Y	278-286	7.5yr 2.5/3 7.5yr 3/4	fibric	coarse	8	4	*P. virginica*	*N. luteum or N. odorata*		horizontal bands of *N. luteum or N. odorata.* live roots of *P. virginica*
Z	286-292	7.5yr 2.5/N	hemic	fine	6	3		? *Panicum sp., N. luteum or N. odorata*	band at bottom of horizon	distinct break in horizon, less consolidated hemic material, layer of charcoal at bottom of horizon.
AA	292-295	7.5yr 3/4	fibric	fine	8	4	*P. virginica*	*N. luteum or N. odorata*		fine fibric sediment with live roots of *P. virginica* through horizon
BB	295-310	7.5yr 2.5/2	fibric	fine	8	4	*P. virgincia*	?		reddish brown fine, firm fibric sediment with *P. virginica* roots.
CC	310-346/348	7.5yr 2.5/1 7.5yr 2.5/3	hemic	fine	6	4		? *Ludwigia sp., N. luteum or N. odorata*		hemic sediment with mottled dark brown and reddish brown color
DD	346/348-361	7.5yr 2.5/3	fibric	fine	6	4		?		mass of fine root hairs reddish orange in color with little decomposed organic associated with horizon
EE	361-380	7.5yr 2.5/1	sapric	fine, blocky	6,10	4		Open Water		blocks of fine textured organic material with roots throughout cracks between blocks
FF	380-395	7.5yr 2.5/1	sapric	fine platy	8,10	4		Open Water		platy chunks of very firm fine organic material with roots between plates
GG	395-403	7.5yr 2.5/1	sapric	fine platy	8,10	4		Open Water		very similar to above probably same horizon.
HH	403-413	7.5yr 2.5/N	mineral	clay	8				fragments throughout, pockets of ash	dense clay/silt mineral horizon with numerous charcoal fragments, pockets of very fine texture light gray/brown ash throughout horizon.

Horizon characterization and plant fragment identification of sediment core sampled at site FMb-2A, Floating Marsh Community Type FMb. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	85-100		litter		3	3	*P. hemitomon* *P. densiflorum*	*P. hemitomon* *Polygonum sp.*		live and dead stem, root and shoots *of P. hemitomon* and *P. densiflorum*, small amount of sapric sediment
B	100-105	7.5yr 2.5/1	hemic	coarse crumbly	8	3		*P. hemitomon,* *N. luteum or* *N. odorata,* *Polygonum sp.*		coarse flaky texture when rubbed, seeds of *P. hemitomon* and *N. luteum*
C	105-112	7.5yr 2.5/2	hemic	coarse	8	4		*Ludwigia sp.,* *N. luteum*		more consolidated and lighter brown then above horizon, seeds of *Ludwigia* sp. *and N. luteum*, rhizome of *N. luteum*
D	112-117	7.5yr 2.5/N 7.5yr 2.5/1	mineral	fibric grainy	8			?	fragments between fibric and mineral interfaces	two layers of mineral with charcoal fragments at top of each, uncoated sand grains in mineral layers bottom layer increasing in sand content with depth, organic layer between mineral layers fibric texture.

Horizon characterization and plant fragment identification of sediment core sampled at site FMb-3A, Floating Marsh Community Type FMb. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	65-67/73	7.5yr 2.5/2	sapric	fine	4	4		? *N. luteum or N. odorata*		loose floculant layer, fragments of *N. luteum* or *N. odorata*
B	67/73-71/77	7.5yr 2.5/2	litter		3	3		*Polygonum sp.* *Scirpus cubensis,* *Salvinia minima*		well preserved fragments of *Polygonum* sp. *Scirpus cubensis* and *Salvinia minima* frond, little or no organic sediment
C	71/77-79	7.5yr 4/4 7.5yr 3/3	litter		3	4		*Polygonum sp.* *Cicuta mexicana*		almost all stem material little or no organic sediments, *Polygonum* with a large diameter and tan stem, *Cicuta mexicana*
D	79-95	7.5yr 2.5/2	hemic	flaky crumbly	8	3		*Panicum sp.*		flaky hemic sediment, fragments of *Panicum* root and stem
E	95-108	7.5yr 2.5/2	hemic	fine	8	4	*N. odorata or N. luteum*	*Panicum sp.,* *S. lancifolia, N. lutuem or N. odorata, Polygonum sp.*	scattered fragments	fine more sapric hemic sediment, live roots of *N. odorata* or *N. luteum*, charcoal fragments throughout horizon, fragments of *Panicum* sp.
F	108-111	7.5yr 3/3	hemic	fine	8	4		*S. lancifolia,* *N. odorata or N. luteum*		*N. luteum* or *N. odorata* rhizome at top of horizon, may also have *S. lancifolia* or *C. jaminsence.*
G	111-120	7.5yr 2.5/2	hemic	coarse	8	3		? *Panicum sp.,* *N. luteum or N. odorata*	bands at 112 and 115	hemic sediment overall with uncoated sand content and pockets around areas of charcoal concentrations, fragments of *Panicum* sp. several bands of charcoal near top of horizon
H	120-123	7.5yr 2.5/2	hemic	coarse	8	5		?		hemic, similar to above but with reddish tint
I	123-	7.5yr 2.5.N	mineral	grainy	8					uncoated sand

Horizon characterization and plant fragment identification of sediment core sampled at site FMa(*S. cubensis*)-2A, Floating Marsh Community Type FMa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	114-124	7.5yr 2.5/2	sapric	fine	2	5		Open Water *L. spongia*		loose floculant, leaf and seed pod of *L. spongia* most likely very recent
B	124-143	7.5yr 2.5/2	sapric	fine	7	1		Open Water *Polygonum sp.* *S. cubensis*		more consolidated sapric sediment, roots and fragments of *Polygonum* sp. reddish roots probably of *S. cubensis*
C	143-165	7.5yr 2.5/2	sapric	fine	6	4		Open Water *Ludwigia sp. ?*		less consolidated then above horizon, scattered fragments one possibly *Ludwigia sp.*
D	165-186	7.5yr 2.5/2	sapric	fine	6	4		Open Water *Polygonum sp.?*		clear break at upper boundary, as if different parent material, several leaves in good condition between horizons as if caught in anaerobic layer
E	186-193	7.5yr 2.5/2	hemic	blocky	6,9	4		?		blocky aggregates of more fibric sediment, 10-13 cm in diameter, overall hemic sediments
F	193	7.5yr 2.5/1	mineral	sand	6					sand sapric complex, no charcoal identified.

Horizon characterization and plant fragment identification of sediment core sampled at site FMa(*P. hemitomon*)-1A, Floating Marsh Community Type FMa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	45-48.5		litter		8	5	*P. hemitomon*	*P. hemitomon*		live and dead *P. hemitomon* stem and root fragments, little or no decomposed organic sediment
B	48.5-53	7.5yr 2.5/2	hemic	coarse crumbly	8	3	*P. hemitomon*	*P. hemitomon*		loose flaky hemic sediment appears to be small fragments of *P. hemitomon* stem, live and dead stem and root fragments of *P. hemitomon.*
C	53-56	7.5yr 2.5/2	hemic	coarse crumbly	8	4	*P. hemitomon*	*P. hemitomon*		more consolidated then horizon above, smaller fragments of similar composition, live roots and dead roots of *P. hemitomon*.
D	56-60	7.5yr 2.5/N 7.5yr 7/1	mineral	grainy	8		*P. hemitomon*	*P. hemitomon*	very small granular fragments at top of horizon	upper horizon small granular charcoal, very dark surface horizon grading to lighter gray with increase in sand, live *P. hemitomon* roots in upper part of mineral horizon.

Horizon characterization and plant fragment identification of sediment core sampled at site FMa(*P. hemitomon*)-3A, Floating Marsh Community Type FMa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	33-54		litter		3	4	*Panicum hemitomon*	*Panicum hemitomon*		stems and roots of *Panicum hemitomon*, come coarse crumbly substrate at base of horizon primarily dead stem fragments
B	54-71	7.5yr 2.5/2	hemic	coarse crumbly	8	3	*Panicum hemitomon*	*Panicum hemitomon*		coarse crumbly fibric sediment, live and dead roots of *P. hemitomon*
C	71-83	7.5yr 2.5/2	hemic	coarse crumbly	8	5	*Panicum hemitomon*	*Panicum hemitomon*	distinct layer of *P hemitomon* fragments at 77.5 cm and bottom of horizon	coarse crumbly fibric sediments more consolidated then above, *P. hemitomon* stolons, *P. hemitomon* charcoal in layers at 77.5 cm and at base of horizon.
D	83-87	7.5yr 2.5/1	sapric	fine	6	4	*Panicum hemitomon*	*Panicum hemitomon*		dark sapric sediment, no large fragments of charcoal or plant, live roots of *P. hemitomon*
E	87-	7.5yr 2.5/N	mineral	granular	7					sandy organic mineral sediment, very dark but no perceptible charcoal fragments

Horizon characterization and plant fragment identification of sediment core sampled at site SMa-1A, Shallow Marsh Community Type SMa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	52-61	7.5yr 4/1	sapric	plastic	7	2	*P. cordata* *P. hemitomon*	*P. cordata* *P. hemitomon*		firm organic clay silt sediment, infiltrated with *P. cordata*, *Panicum hemitomon* roots.
B	61-67	7.5 yr 4/1	mineral	plastic	7	4	*P. hemitomon*	*P. hemitomon*		firm plastic sediment, few roots of *P. hemitomon*, organic accretions <.25 cm and large sand grains, fragments of *P. hemitomon*, live roots of these species as well
C	67-73	7.5yr 5/1	mineral	plastic	7		*P. hemitomon*	*P. hemitomon*		firm plastic clay sediment, live *P. hemitomon*, large sand grains and accretions as above but slightly larger.

Horizon characterization and plant fragment identification of sediment core sampled at site SMa-2A, Shallow Marsh Community Type SMa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	94-120		litter		3	4	*P. cordata* *P. hemitomon* *P. punctatum*	*P. cordata* *Panicum sp.*		leaf and stem litter and some rhizomes of *P. cordata*, stolons of *P. punctatum and P hematomon*, predominantly plant fragments with pick-up in organic at bottom of horizon
B	120-126	7.5yr 2.5/2 10r 3/6	fibric	coarse	8	4	*P. cordata*	*P. cordata, Ludwigia sp, A. australis, Polygonum sp.*	stem fragment in bottom of horizon surface burns	consolidated, older *P. cordata* rhizome and root hairs, at bottom of horizon several large plant fragments of possibly *Eupatorium* sp. or *Amaranthus australis*.
C	126-163	7.5yr 2.5/2	sapric	fine	8	2	*P. cordata*	*Panicum sp. Ludwigia sp., A. australis, N. luteum or N. odorata*		firm sapric sediment, *P. cordata* roots and root hairs, small plant fragments, small hard organic accretions
D	163-174	7.5yr 2.5/2	hemic	fine, sinuous	8	2		*N. luteum or N. odorata*		firm hemic sediment, spongy with some sapric organic and pulls apart along distinct layers, *N. luteum* or *N. odorata* rhizome,
E	174-178	7.5yr 2.5/2	fibric	fine firm	8	3		?		dense fibric sediment, plant fragments of possibly *Eupatorium* sp. or *Amaranthus australis*
F	178-184	7.5yr 2.5/1	hemic	grainy	8	3		?	layer of small grain like fragments	dark grainy coarse hemic sediment, numerous small charcoal fragments like small grains of sand.
G	184-187	7.5yr 2.5/2	fibric	coarse	8	4		*N. luteum or N. odorata*		coarse fibric sediment, remnant root and rhizome of *N. odorata* or *N. luteum*
H	187-194	7.5yr 2.5/1	fibric	coarse	8	4		*N. luteum or N. odorata*		firm coarse fibric sediment, rootlets of *N. luteum* or *N. odorata*
I	194-	7.5yr 2.5/1	minerals	plastic grainy	8					clayey fine sand

Horizon characterization and plant fragment identification of sediment core sampled at site SMa-3A, Shallow Marsh Community Type SMa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	54-61	7.5/yr 3/4	litter		3	4	*S. lancifolia* *P. virginica*	*P. virginica* *S. lancifolia*		leaf and stem litter of *S. lancifolia* and *P. virginica*
B	61-69	7.5/yr 2.5/2	fibric	crumbly granular	8	3	*S. lancifolia* *P. virginica*	*Panicum sp.* *S. lancifolia,* *P. virginica,* *C. mexicana,* *Bidens sp.*		crumbly granular fibric sediment, *S. lancifolia* and *P. virginica* live and dead roots, *Panicum hematomon* fragments
C	69-82	7.5/yr 2.5/2	fibric	coarse	8	3	*P. virginica*	*?* *P. virginica,* *Panicum sp.,* *Polygonum sp.*		fibric sediment with open pockets and numerous *P. virginica* roots, *Panicum* stem fragments
D	82-96	7.5/yr 2.5/2 7.5yr 4/6	fibric	coarse	8	3	*S. lancifolia*	*?* *S. lancifolia* *P. virginica* *Panicum sp.*		light and dark horizontal bands in horizon, *S. lancifolia* roots and rhizome, *Panicum hematomon* stolon fragments (dead)
E	96-108	7.5/yr 2.5/3	hemic	crumbly pasty	8	3	*S. lancifolia* *P. virginica*	*S. lancifolia* *P. vriginica* *Panicum sp.*		crumbly pasty hemic peat, live and dead roots of *P. virginica* and *S. lancifolia*, stolons of *Panicum* sp. at base of horizon.
F	108-122	7.5/yr 2.5/2 7.5yr 4/6	hemic	crumbly	8	3	*S. lancifolia* *P. virginica*	*S. lancifolia*		similar to horizon above with the exception that *Panicum* sp. stolons are in the top of this horizon
G	122-150	7.5/yr 3/2	hemic	fine	8	1	*P. virginica*	*Panicum sp.* *S. lancifolia,* *P. virginica,* *Polygonum sp.*		numerous dead *S. lancifolia* roots, live and dead *P. virginica* roots.
H	150-197	7.5/yr 2.5/2	hemic	fine	8	1	*P. virginica*	*N. luteum or* *N. odorata,* *S. lancifolia,* *P. virginica,* *D. verticillata*	scattered fragments	moderatly compacted hemic sediment with live P. virginica roots decreasing wih depth, distinct break in sediments at base of horizon, live *P. virginica* brige gap and into next horizon
I	197-234	7.5/yr 2.5/2	hemic	fine	8	5	*P. virginica*	*S. lancifolia,* *N. luteum or* *N. odorata,* *D. verticillata,* *Ludwigia sp.*		consolidated hemic sediment, live roots of *P. virginica*
J	234-	7.5yr 4/1	mineral	plastic	8					Clay

Horizon characterization and plant fragment identification of sediment core sampled at site SMb-1A, Shallow Marsh Community Type SMb. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	45-65	7.5yr 2.5/2	fibric	coarse flaky	6	3	*S. lancifolia* *C. jamaicense*	*S. lancifolia* *C. jamaicense*		rhizome and roots of *S. lancifolia* near top of horizon, *C. jamaicense* shoot vertical in horizon leaf tissue surrounding shoot, fibric flaky sediment
B	65-79	7.5yr 2.5/2 10r 3/4	fibric	fine	8	3	*S. lancifolia* *C. jamaicense*	*S. lancifolia* *C. jamaicense*		fine fibric sediment, *C. jamaicense* rhizomes and roots horizontal in horizon
C	79-91	7.5yr 2.5/2	fibric	coarse	8	4	*S. lancifolia* *C. jamaicense*	*S. lancifolia* *C. jamaicense*		less consolidated fibric sediment, large plant fragments create pockets in horizon, *C. jamaicense* rhizomes and roots, *S. lancifolia* live and dead roots
D	91-99	7.5yr 2.5/2	fibric	coarse	8	4	*S. lancifolia* *C. jamaicense*	*S. lancifolia* *C. jamaicense*		more consolidated then above horizon, fibric sediment, large fragments of *C. jamaicense* live and dead roots of *C. jamaicense* and *S. lancifolia*
E	99-106	7.5yr 2.5/2	fibric	coarse	8	4	*S. lancifolia*	*C. jamaicense* *N. luteum or* *N. odorata*	small fragments at bottom of horizon	fine fibric sediment, horizontal rhizomes and roots of *N. luteum*, live and dead roots *of S. lancifolia* and *C. jamaicense*, small charcoal fragments in bottom of horizon
F	106-119	7.5yr 2.5/1	hemic	fine	8	5		? *S. lancifolia* *C. jamaicense* *N. odorata*		loose fine hemic sediment, *remnant S. lancifolia* and *C. jamaicense* roots.
G	119-123	2.5yr 3/6	fibric	sinuous	8	5		*C. jamaicense* *S. lancifolia*		light colored sinuous fibric sediment, little or no fine organic sediment, most likely *S. lancifolia* shoot base
H	123-136	7.5yr 2.5/2	fibric	firm fine	8	4		*C. jamaicense*		fine firm fibric sediment, *remnant S. lancifolia* and *C. jamaicense* roots.
I	136-143	7.5yr 2.5/2	fibric	coarse	8	4		*C. jamaicense*		break between H and I horizon, coarse fibric sediment, *S. lancifolia* and *C. jamaicense* root fragments
J	143-157	7.5yr 2.5/2	fibric	fine firm	8	4		*C. jamaicense*	band at 149-150 cm scattered fragments throughout horizon	firm fine fibric sediment, scattered unidentified plant fragments, layer of charcoal fragments between 149-150 cm, scattered fragments throughout horizon
K	157-165	7.5yr 2.5/3	fibric	fine firm	8	5		*N. luteum or* *N. odorata* *C. jamaicense*	layer at bottom of horizon	firm fine fibric sediment, *N. luteum* or *N. odorata* rootlets, charcoal layer in bottom of horizon.
L	165-179	7.5yr 2.5/3	fibric	very fine very firm	8	5		*N. luteum or* *N. odorata* *C. jamaicense*		compact very fine sediment, *N. luteum* or *N. odorata* rootlets

Core sampled at site SMb-1A, continued.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
M	179-185	7.5yr 2.5/2	hemic	fine	8	5		*N. luteum or* *N. odorata* *C. jamaicense*	layer at top of horizon	fine hemic sediment, remnant *S. lancifolia* and *C. jamaicense* roots. layer of charcoal fragments at top of horizon
N	185-188	7.5yr 2.5/N 7.5yr 2.5/2 7.5yr 6/1	sapric	plastic	8	5		*N. luteum or* *N. odorata* Open Water	layer at top of horizon	fine plastic sediment, charcoal fragments at top of horizon, composition similar to M horizon with pick up in sapric organic content, silty clay vertical pocket at edge of core
O	188-189	7.5yr 2.5/1 7.5yr 2.5/N	mineral	plastic grainy	8				layer at top of horizon	charcoal fragments at top of horizon, sapric organic sediment with scattered mineral sands

Horizon characterization and plant fragment identification of sediment core sampled at site SMb-2A, Shallow Marsh Community Type SMb. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	80-100	7.5yr 2.5/3	litter		3	2	*T. latifolia*	*T. latifolia*		base of water column detrital *T. latifolia* leaves, live shoot bases
B	100-107	7.5yr 3/3	sapric	fine	4	3	*T. latifolia*	*T. latifolia* *Panicum sp.* *Cicuta mexicana* *Polygonum sp.*		*T. latifolia* root and rhizome, dead fragments of *Cicuta mexicana*, *Polygonum* sp. and *Panicum* sp., loose partially consolidated floculant
C	107-118/122	7.5yr 2.5/3	hemic	crumbly	6	3		*Polygonum sp.*		crumbly peat with two species of *Polygonum*
D	118/122-123/126	7.5yr 3/4	fibric	sinuous	8	4		*N. luteum* *S. lancifolia*		root channel and rootlets of *N. luteum*, fibrous peat
E	123/126-139	7.5yr 2.5/1	hemic	crumbly	8	4		*?* *N. luteum*		loose crumbly hemic sediment, *N. luteum* roots
F	139-148	7.5yr 2.5/N	mineral	sand	7				layer of charcoal at top of mineral horizon	dark grainy horizon of sand/organic complex, old root channels penetrate layer, charcoal at top of horizon

Horizon characterization and plant fragment identification of sediment core sampled at site SMb-3A, Shallow Marsh Community Type SMb. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsel color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	61-83	7.5yr 3/4 5y 7.4	litter		3	3	*S. lancifolia* *C. jamaicensi*	*S. lancifolia,* *C. jamaicense*		live and dead shoot, root and rhizome fragments of S. lancifolia and *C. jamaicense* with little or no decomposed organic
B	83-93	7.5yr 2.5/2	hemic	firm	8	4	*S. lancifolia* *C. jamaicense*	*S. lancifolia,* *C. jamaicense*		hemic, fibrous, *S. lancifolia* and *C. jamaicense* present live and dead roots and rhizomes
C	93-99	7.5yr 2.5/3	hemic	firm	8	4		*?* *Polygonium sp.*		indescript light brown color
D	99-103	7.5yr 2/2	sapric	coarse	6	4		*Polygonum sp.,* *Cicuta mexicana,* *D. verticillata*		more sapric horizon then above with fragments of *Polygonum* and *Cicuta mexicana* or *Eupatorium sp.*
E	103-109	7.5yr 2.5/3 charcoal 7.5yr 2/N	hemic	firm	8	5		*Polygonum sp.,* *C. jamaicense,* *Panicum sp.,* *P. cordata,* *N. luteum or* *N. luteum*	distinct band at 108-109	lighter brown hemic sediment with distinct charcoal band at base of horizon. woody plant fragments of *Polygonum C jamaicense* rhizome, *N.* l*uteum* rhizomes and unk grass.
F'	109-135	7.5yr 2.5/2	fibric	firm	8	3	*S. lancifolia*	*N. luteum or* *N. odorata,* *Polygonum sp.* *C. jamaicense* *Panicum sp.* *S. lancifolia*		firm peaty horizon with plant fragments of *Polygonum sp. C. jamaicense* roots, *N. luteum* rhizomes stem fragments of Gramineae and live and dead roots of *S. lancifolia*
G	135-156	7.5yr 2.5/3 7.5yr 2.5/1	fibric	fine dense	8	4	*S. lancifolia*	*N. luteum or* *N. odorata* *C. jamaicense* *S. lancifolia* *Panicum sp.*		horizontal banding of dark and light brown fine dense peat, *N odorata* or *N. luteum* rhizome, *P. hematomon* stolon, *C. jamaicense* roots in lower horizon, *S. lancifolia* roots live and dead, very spongy at bottom of horizon
H	156-163	7.5yr 3/3	fibric	fine	6	4		*N. odorata or* *N. luteum* *Panicum sp.*		lighter brown horizon of spongy peat, dark patches of *N. odorata* or *N luteum.*
I	163-172	7.5yr 2.5/2	fibric	fine	8	4		*S. lancifolia,* *N. odorata or* *N. luteum*		large rhizome of *S. lancifolia*, fragments of *Ploygonum sp.* at top of horizon, Dead *N. odorata* or *N. luteum* roots.
J	172-177	7.5yr 3/4	fibric	fine	8	4		*N. odorata or* *N. luteum, P. cordata*		rhizome and roots of *N. odorata* or *N. luteum*
K	177-196	7.5yr 2.5/2	fibric	fine	8	4		*S. lancifolia* *N. luteum or* *N. odorata*	scattered fragments	fibric peat with large void of decomposed *N. luteum* or *N. odorata* rhizomes, roots of *S. lancifolia*, scattered charcoal fragments

Core sampled at site SMb-3A, continued.

Horizon	Depth cm	Color Munsel color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
L	196-225	7.5yr 2/3	fibric	fine dense	8	5		*N. luteum or N. odorata, S. lancifolia, Ludwigia sp.*		very dense reddish brown horizon of N. luteum or *N. odorata* rhizome and root.
M	225-234/238	7.5yr 2.5/N 7.5yr 3/3 7.5yr 2.5/2	fibric	fine	8	3		*?* *N. luteum or N. odorata, Ludwigia sp.*	distinct band at top of horizon	dark band of charcoal fragments overlying reddish brown the dark brown bands.
N	234/238-241/245	7.5yr 2/4	sapric	fine	6	3		*N. luteum or N. odorata,* Open Water		fine, sapric organic
O	241/245-258/262	7.5yr 2.5/2	sapric	fine	6	3		*N. luteum or N. odorata,* Open Water		sapric organic similar to open-water bottom consistency, less consolidated then horizon L, roots of S. lancifolia and *N. luteum* or *N. odorata*, small unidentified seeds
P	258/262-277	7.5yr 2.5/a	sapric	fine	6,10	4		*N. luteum or N. odorata, S. lancifolia*	thin band at top of horizon	charcoal band at top of horizon, equal consolidation with firm blocky components, distinct break at bottom of horizon with flattened horizontal roots of *S. lancifolia*
Q	277-298	7.5yr 2.5/1	fibric	compact platy	7,10	4		*N. luteum or N. odorata*		multiple layers of firm platy peat and rhizomes of *N. luteum* or *N. odorata*
R	298-	7.5yr 2.5/N	mineral	plastic grainy	7					clayey sand

Horizon characterization and plant fragment identification of sediment core sampled at site SSa-1A, Shrub Swamp Community Type SSa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	0-6		litter	coarse	5	3	*S. caroliniana*	*S. caroliniana*		leaf and twig litter of Salix caroliniana
B	6-26	10r 3/1	hemic	coarse crumbly	8	3	*S. caroliniana*	*S. caroliniana* *C. jaminsence*		hemic crumbly sediment interlaced with *S. caroliniana* roots and rootlets, *C. jaminsence roots.*
C	26-33	7.5yr 2.5/2	hemic	coarse	8	4		*C. jaminsence* *P. virginicum*		hemic sediment, dead plant fragments of *C. jaminsence* root and stolon *and P. virginica* root.
D	33-45	7.5yr 3/3 7.5yr 2.5.2	fibric	coarse	8	4		*C. jaminsence* *S. lancifolia*		light and dark horizontal banding in fibric horizon, *S. lancifolia* and *C. jaminsence* fragments
E	45-49/51	7.5yr 3/3	fibric	coarse	8	4		*S. lancifolia*		horizon dominated by *S. lancifolia* plant fragments.
F	49/51-57	7.5yr 2.5/3	hemic	fine	8	4		*Panicum sp.,* *N. luteum or* *N. odorata*		fine hemic sediment, fragments *of Panicum stems* and *N. luteum* or *N. odorata* rhizomes, unknown plant fragments
G	57-66	7.5yr 2.5/N 7.5yr 2.5/1	fibric	sinuous	8	4		?	layer at top of horizon	charcoal fragments in a layer at top of horizon, below charcoal spongy sinuous sediment
H	66-108	7.5yr 2.5/1	fibric	crumbly	8	2		? *C. jaminsence* *P. virginica* *S. lancifolia*		dark fibric horizon with fragments of *C. jaminsence* dead roots of *P. virginica*, fragments of *S. lancifolia* in bottom of horizon
I	108-118/127	7.5yr 2.5/1	fibric	coarse	8	3		*C. jamaicense,* *Polygonum sp.,* *Panicum sp.*		small fragment of *N. luteum* or *N. odorata* rhizome, dark horizon
J	118/127-128	7.5yr 3/4	fibric	coarse	8	4		*C. jamaicense,* *S. lancifolia,* *N. luteum or* *N. odorata*		dark band down side of horizon, fragments of *S. lancifolia* root, *N. luteum* or *N. odorata* rhizome, and *C. jaminsence.*
K	128-132	10yr 2/2	fibric	coarse	8	4		? *C. jamaicense, N. lutuem or N. odorata*	scattered fragments	charcoal fragments scattered throughout horizon
L	132-140	7.5yr 2.5/2	fibric	fine	8	2		? *C. jamaicense, N. luteum or N. odorata*		reddish brown horizon, Nuphar root fragments
M	140-147	7.5yr 2.5/3	fibric	coarse	8	5		? *C. jamaicense,* *C. occidentalis,* *N. luteum or* *N. odorata*		

Core sampled at site SSa-1A, continued.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
N	147-154	7.5yr 3/4	fibric	coarse	8	5		*N. luteum or* *N. odorata*	thick charcoal layer at top of horizon	thick layer of charcoal at top of horizon with very fine compact fibrous roots below
O	154-160	7.5yr 2.5/1	fibric	coarse	8	2		*N. luteum or* *N. odorata* *C. jamaicense*	scattered fragments	dark horizon with scattered charcoal fragments
P	160-165	7.5yr 2.5/2	fibric	firm	8	5		? *N. luteum or* *N. odorata* *C. jamaicense*		firm fibric sediment, unknown fine orange brown rootlets
Q	165-	7.5yr 2.5/N	mineral	plastic grainy	7					clayey sand

Horizon characterization and plant fragment identification of sediment core sampled at site SSa-2A, Shrub Swamp Community Type SSa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	39-46		litter	coarse	5	4	*Salix caroliniana*	*S. caroliniana*		litter of *S. caroliniana* leaves and twigs little or no decomposed organic.
B	46-55	10r 2.5/1	hemic	coarse crumbly	8	4	*S. caroliniana*	*S. caroliniana*		rootlets of *S. caroliniana* in hemic crumbly peat
C	55-66	5yr 2.5/2	hemic	coarse crumbly	8	5	*S. caroliniana* *P. virginica*	*S. caroliniana*		more compacted hemic crumbly sediment, with live roots of *S. caroliniana* and *P. virginica*
D	66-77	7.5yr 2.5/N 7.5yr 7/1	mineral	granular	8		*S. caroliniana* *P. virginica*		fragments at top of horizon	sandy organic mineral horizon, numerous charcoal fragments primarily at top of horizon, pockets of uncoated sands lighter then surrounding.

Horizon characterization and plant fragment identification of sediment core sampled at site SSa-3A, Shrub Swamp Community Type SSa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	62-76	7.5yr 2.5/2	litter hemic	coarse	8	3	*S. caroliniana* *P. virginica*	*S. caroliniana* *P. virgincia*		leaf litter and woody roots of *S. caroliniana* up to 4 cm. hemic sediment dispersed
B	76-89	7.5yr 2.5/2	hemic	coarse	8	3	*S. caroliniana* *P. virginica*	*S. caroliniana,* *P. virginica,* *S. latifolia,* *D. verticillata,* *Polygonum sp.* *Hydrocotyle sp.,* *T. thelypteroides*		fewer rootlets with several large roots *of S. caroliniana* and network of *P. virginica* interspersed in hemic sediment
C	89-102	7.5yr 3/2	hemic sapric	pasty blocky	8	3	*P. virginica*	*Panicum sp.,* *Polygonum sp.,* *S. caroliniana,* *P. cordata*		hemic overall with sapric portion pasty, *Panicum* stem fragments, *P. virginica* live roots blocky fracture of horizon
D	102-109	7.5yr 2.5/2	hemic	coarse	8	4	*P. virginica*	*?* *Panicum sp.,* *P. cordata,* *M. cerifera*	band at 106 cm	coarse hemic texture, several large live roots of *P. virginica.* distinct break in horizon at 106 cm charcoal layer below. well preserved leaf of *M. cerifera.*
E	109-115	7.5yr 2.5-2	hemic	coarse crumbly	8	4	*P. virginica*	*?* *N. luteum or* *N. odorata,* *Polygonum sp.,* *Panicum sp.*		increase in consolidation and fibric component then horizon D, woody plant fragments and *N. luteum* or *N. odorata* rhizome, *Panicum* sp. stems, crumbly texture
F	115-125	7.5yr 2.5-2	hemic	coarse	8	4	*P. virginica`*	*?* *P. virginica,* *Panicum sp., N. luteum or N. odorata*		live *P. virginica* and *Panicum sp.* stems in bottom of horizon, coarse hemic texture.
G	125-140	7.5yr 2.5-2 7.5yr 4/4	fibric	coarse	8	4	*P. virginica*	*S. lancifolia*		fibric firm texture in light and dark bands, live *P. virginica* roots, dead roots of *Panicum* plus layer which may be *Panicum* leaves
H	140-152	7.5yr 2.5-2	fibric	fine	6	4		*S. lancifolia*		not as consolidated as above with mix of fibric and sapric sediment
I	152-167	7.5yr 2.5-2 7.5yr 4/4	fibric	fine	8	4	*P. virginica*	*S. lancifolia,* *N. luteum or* *N. odorata*		firm fibric sediment, banded light and dark horizontally, live *P virginica* roots, S. lancifolia and *Panicum sp.* fragments.
J	167-187	7.5yr 2.5-2	hemic	fine	8	4	*P. virgincia*	*?* *S. lancifolia, N. luteum or N. odorata*		finer texture and more compact then above horizon
K	187-212	7.5yr 2.5/1	hemic	fine	8	5	*P. virginica*	Open Water, *S. lancifolia, N. luteum or N. odorata*		less fibric and pick up in sapric component, live roots of *P. virginica* throughout, distinct break at bottom of horizon

Core sampled at site SSa-3A, continued.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
L	212-231/236	7.5yr 2.5/2	hemic	fine	8	4		? *Polygonum sp.*, *E. capillifolium*		similar to horizon above, may be the same with exception of break.
M	231/236-236/240	7.5yr 2.5/2	hemic	very coarse	8	4		*D. verticillata*, *E. capillifolium*, *N. luteum* or *N. odorata*		woody herbaceous fragments possible *Eupatorium sp.* very coarse
N	236/240-243	7.5yr 2.5/2	hemic	platy	8	4		*N. luteum or N. odorata*		firm compacted layers, platy
O	243-253	7.5yr 2.5/2	hemic	fine	8	3		? *N. luteum or N. odorata*		Woody herbaceous fragments possibly *Eupatorium sp.*
P	253-259	7.5yr 2.5/2	sapric	fine	6	2		Open Water		loose sapric sediment no large plant fragments slight slump of core
Q	259-301	7.5yr 2.5/2	sapric	fine	6,10	2		Open Water		7-12 cm soft fine organic aggregates at bottom of horizon with other sediments loose fine sapric
R	301-331	7.5yr 2.5/2	sapric	fine	6	5		Open Water *Eupatorium sp.*	scattered fragments	more consolidated sapric sediment with scattered charcoal fragments
S	331-	7.5yr 2.5/N	mineral	plastic	7					clay

Horizon characterization and plant fragment identification of sediment core sampled at site DMa-1A, Deep Marsh Community Type DMa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	148-162		litter		3	4	*N. luteum* *C. demersum*	Open Water *N. luteum* *T. latifolia*		loose floculant and litter of N. luteum and T. latifolia, live *N. luteum* feeder roots and *C. demersum*,
B	162-182	7.5yr 2.5/2	sapric	fine floculant	6	3	*N. luteum*	*N. luteum,* *T. latifolia,* *S. cubensis,* *Polygonum sp.,* *Panicum sp.*		consolidated sapric sediment, plant fragments of *T. latifolia* and *Polygonum* sp., live and dead anchor root and rhizome of *N. luteum*
C	182-197	7.5yr 2.5/1	sapric	fine	7, 10	4	*N. luteum*	Open Water	scattered fragments	dark horizon, small firm organic aggregates, mineral particles throughout horizon, two *N. luteum* anchor roots, charcoal fragments of *Panicum sp.*
D	197-202	7.5yr 2.5/N	mineral	grainy	7		*N. luteum*			sand mineral horizon, live and dead N. luteum roots penetrating sand, no charcoal fragments but horizons is black.

Horizon characterization and plant fragment identification of sediment core sampled at site DMa-2A, Deep Marsh Community Type DMa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	192-205	7.5yr 2.5/2	litter		3	2	*N. luteum* *H. verticillata*	Open Water *N. luteum*		apical bud of *N. luteum*, *H. verticillata* stems and roots, dead leaf and rhizome fragments of *N. luteum*, detritus sediment
B	205-230	7.5yr 2.5/2	sapric	fine floculant	5	2	*N. luteum*	Open Water		loose floculant, small plant fragments, seeds of *N. luteum*, live rhizome and lateral feeding roots of *N. luteum*
C	230-238	7.5yr 2.5/2	sapric	fine	6	3	*N. luteum*	Open Water *N. luteum or* *N. odorata*		consolidated floculant slight increase in fiber content, *N. luteum* rhizome and horizontal roots, *N. luteum* seeds present.
D	238-246	7.5yr 2.5/2	hemic	coarse crumbly	8	3	*N. luteum*	*N. luteum or* *N. odorata* *Ludwigia sp.*		hemic coarse crumbly sediment, *N. luteum* anchor roots, black and tan *N. luteum* seeds
E	246-261	7.5yr 2.5/2	fibric	coarse	8	4	*N. luteum*	?		spongy fibric sediment, platy delamination zones, *N. luteum* anchor roots penetrate perpendicularly through horizon.
F	261-	7.5yr 2.5/2	mineral	plastic granular	8					sandy clay mineral sediment

Horizon characterization and plant fragment identification of sediment core sampled at site DMa-3A, Deep Marsh Community Type DMa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	70-103	7.5yr 2.5/3	litter				*L. spongia*	*Eupatorium sp. or Ludwigia sp.*		loose litter layer of *N. odorata*, *N. luteum* and *L. spongia*, live roots of *L. spongia* throughout, dead stems of *Eupatorium* sp. or *Ludwigia* sp.
B	103-106	7.5yr 2.5/2	hemic	fine firm	3	5		*E. baldwinii* *Eupatorium sp.*		layer of *E. baldwinii* at top of horizon, live root hairs of *L. spongia*, aggregates of firm sapric sediment with numerous plant fragments of *Eupatorium* sp.
C	106-118	7.5yr 2.5/3	fibric	coarse	8	4	*N. luteum or N. odorata*	*C. mexicana* *N. luteum or N. odorata*		root of *Eupatorium* sp. in top of horizon, live roots of *N. odorata* or *N. luteum* throughout horizon, dead rhizome and seeds of *N. luteum* or N. *odorata* and fragments of *Eupatorium* sp.
D	118-130	7.5yr 2.5/3	fibric	coarse	8	4	*N. luteum or N. odorata*	*N. luteum or* *N. odorata,* *Panicum sp.,* *C. mexicana*		very coarse, small organic aggregates in sediment, large anchor roots of *N. luteum* or *N. odorata*, top of horizon plant fragments of *Ludwigia* sp. or *Eupatorium* sp., stems of *Panicum* sp.
E	130-143	7.5yr 2.5/3	fibric	coarse	8	4		*N. luteum or* *N. odorata* *Panicum sp.,* *C. mexicana*		horizontal banding of horizon darker bands are fragments of *N. odorata* or *N. luteum* rhizomes. fragments of *Panicum* sp. stolon
F	143-148	7.5yr 2.5/3	fibric	spongy	8	4		*N. luteum or* *N. ordorata* *Panicum sp.?*		fibric sediment, stolon of *Panicum* sp. possibly *C. jaminsence* root and rhizome
G	148-153	7.5yr 2.5/3	fibric	spongy	8	4		*?*		darker fibric sediment peat particles unk.
H	153-155	7.5yr 3/3	fibric	spongy	8	4		*S. lancifolia*		lighter band fragments of *S. lancifolia*, fibric sediment
I	155-160	7.5yr 2.5/N	fibric	spongy	8	5		*S. lancifolia* *N. luteum or* *N. odorata* *C. jamaicense*	thin band at 156 cm	fibric sediment, dead fragments of *S. lancifolia* and *N. odorata* or *N luteum* roots, thin charcoal band at top of horizon 156 cm
J	160-	7.5yr 2.5/N	mineral	grainy	8				fragments at top of horizon	uncoated sands, some clay silt, charcoal fragments accumulated just above mineral substrate

Horizon characterization and plant fragment identification of sediment core sampled at site OWa-1B, Open Water Community Type OWa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	245-274	7.5yr 2.5/2	sapric	fine floculant	2	1		Open Water		loose floculant fine sediment, several large plant fragment
B	274-279/282	7.5yr 2.5/2	sapric	fine	5	3		Open Water		more consolidated, smaller plant fragments
C	279/282-284/290	7.5yr 2.5/2	sapric	fine granular	7	4		Open Water	scattered fragments	granular organic aggregates 0.25-0.5 cm mixed with plant fragments and scattered charcoal
D	284/290-289/294	7.5yr 2.5/2	mineral	pasty grainy	7	4		Open Water	layer of fragments overlying band of uncoated mineral sands	charcoal fragments at top of horizon overlying uncoated sands 0.5 cm thick.
E	289/294-298	7.5yr 2.5/2	sapric	fine blocky	6	3		Open Water		fine loose floculant, plant fragments and granular organic aggregates 2.5-5 cm
F	298-362	7.5yr 2.5/3	hemic	coarse blocky	8	2		?		spongy fibric sediment N. luteum anchor root channels running perpendicular through horizon, large soft blocky aggregates at bottom of horizon
G	362-396	7.5yr 2.5/2 7.5yr 2.5/3	hemic	fine pasty blocky	8	4		?		blocky hemic sediment, pasty texture, outside and between blocks darker blocks then internal to blocks, fracture into plates at bottom horizon
H	396	7.5yr 2.5/2	mineral	grainy	8					sandy clay

Horizon characterization and plant fragment identification of sediment core sampled at site OWa-2A, Open Water Community Type OWa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	240-253	7.5yr 2.5/2	sapric	fine floculant	2	1	*Hydrilla verticillata*	Open Water		flocculent, *H. verticillata* roots and seed
B	253-325	7.5yr 2.5/2	sapric	fine blocky	6	2		Open Water		more consolidated, plant fragments, several hemic sediment aggregates in bottom of horizon 5-8 cm
C	325-347	7.5yr 2.5/2	sapric	fine blocky	6,9	2		Open Water		firm fine sapric sediment, aggregates of fine more consolidated sapric sediment 10-13 cm, several large plant fragments.
D	347-362	7.5yr 2.5/2	sapric	fine	5	2		Open Water *N. luteum*		plant fragments possibly *Eupatorium* sp., abscission scar of *N. luteum*, fine consolidated sapric sediments
E	362-380	7.5yr 2.5/2	sapric	fine granular blocky	7	4		Open Water		firm sapric sediment, platy very firm sediment at bottom of horizon, granular organic aggregates, vertical root channels penetrating layers
F	380	7.5yr 2.5/2	mineral	plastic grainy	7					sandy clay

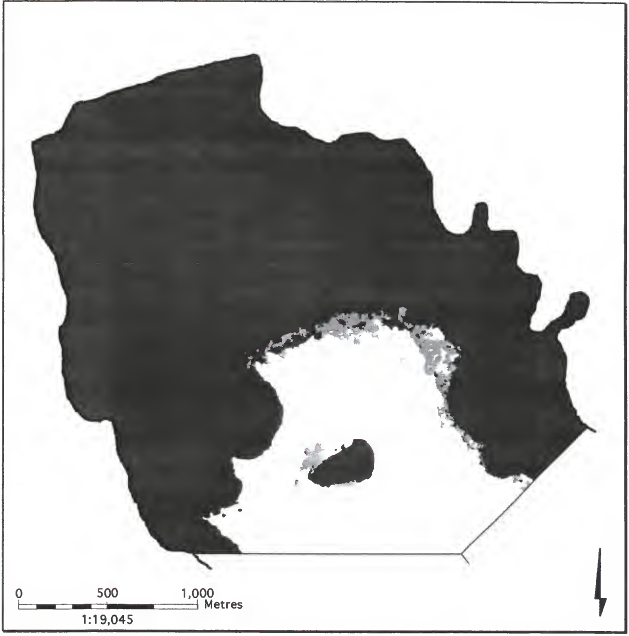
Horizon characterization and plant fragment identification of sediment core sampled at site OWa-3B, Open Water Community Type OWa. Color characterized using Munsell soil color charts (1994). Structure code and boundary code characterization values identified in materials and methods section.

Horizon	Depth cm	Color Munsell color	Composition	Texture	Structure Code	Boundary Code	Live Plant Fragments	Dead Plant Fragments	Charcoal	Comments
A	172-191	7.5yr 2.5/2	sapric	fine floculant	2	1		Open Water		unconsolidated floculant organic sediment, no fragments
B	191-210	7.5yr 2.5/2	sapric	fine floculant	2	1		Open Water		more consolidated, pick up in large plant fragments
C	210-224	7.5yr 2.5/2	sapric	fine floculant	3	1		Open Water		slightly more consolidated, increase in size and number of fragments
D	224-284	7.5yr 2.5/2	sapric	fine	3	1		Open Water *N. luteum*		pick-up in consolidation, leaf abscission scab of *N. luteum*, other fragments
E	284-296	7.5yr 2.5/2	sapric	fine	4	2		Open Water		consolidated fine organic sediment
F	296-315	7.5yr 2.5/2	sapric	fine	5	3		Open Water		larger and more numerous plant fragments, firmer more consolidated
G	315-328	7.5yr 2.5/2	sapric	fine blocky	6,10	4		Open Water		consolidated fine sapric sediment intermixed with firmer fine sediment aggregate 10-12 cm and smaller aggregates.
H	328-338	7.5yr 2.5/2	sapric	fine platy	10	4		Open Water		firm fine sapric sediment, platy fracture characteristic between fractures plant roots
I	338	7.5yr 2.5/1	mineral	plastic	7					clay fine sand

APPENDIX E

MAPS OF COMMUNITY COVERAGE
AND
MAPS OF COMMUNITY CHANGE

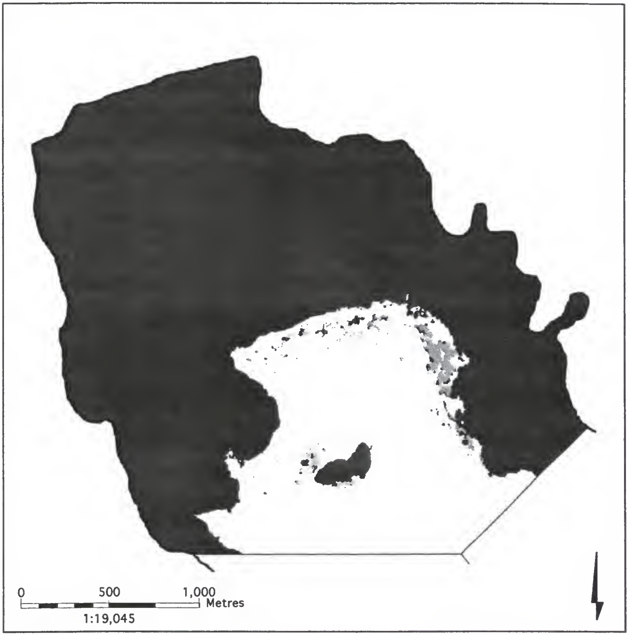
Figure E-1. North Sector, January 22, 1994.



☐	Open Water	133.33
■	Floating/Emerget Wetlands	446.56
▨	Fringing *Nuphar luteum*	12.17

Legend coverage area in hectares

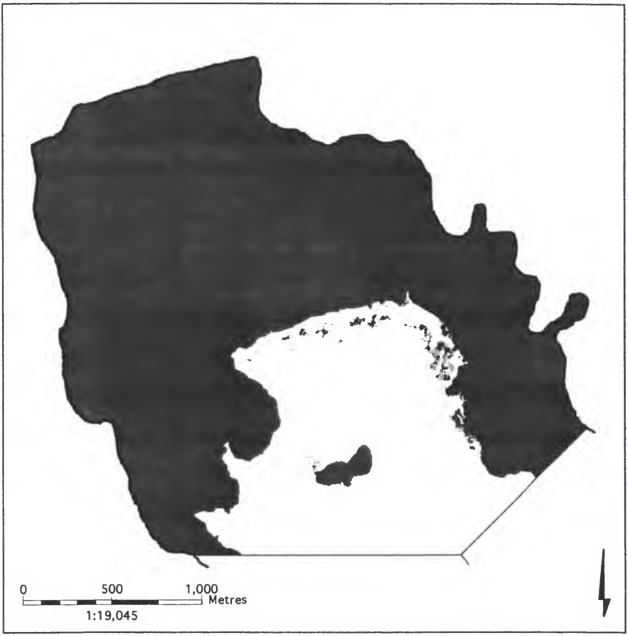
Figure E-2. North Sector, June 13, 1996.



☐	Open Water	155.35
■	Floating/Emergent Wetlands	429.87
▨	Fringing *Nuphar luteum*	6.82

Legend coverage area in hectares

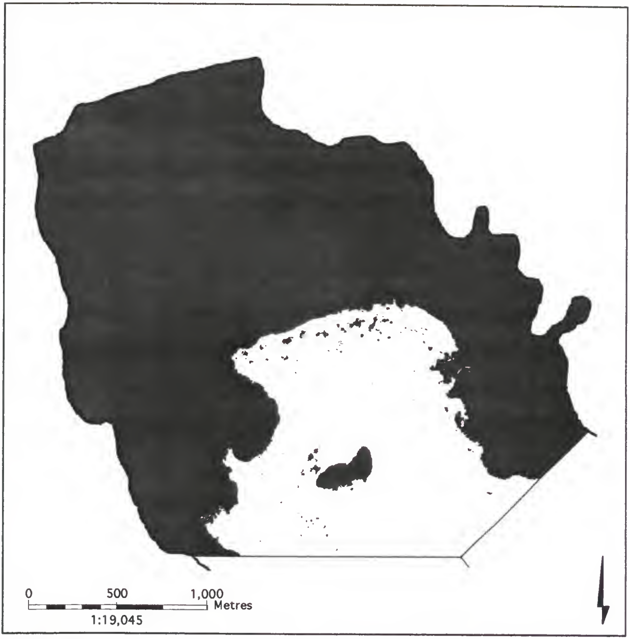
Figure E-3. North Sector, July 23, 1996.



☐	Open Water	160.50
■	Floating/Emergent Wetlands	428.23
▨	Fringing *Nuphar luteum*	3.32

Legend coverage area in hectares

Figure E-4. North Sector, September 24, 1996.



☐	Open Water	161.32
■	Floating/Emergent Wetlands	430.21
▨	Fringing *Nuphar luteum*	0.54

Legend coverage area in hectares

Figure E-5. East(north) Sector, January 22, 1994.

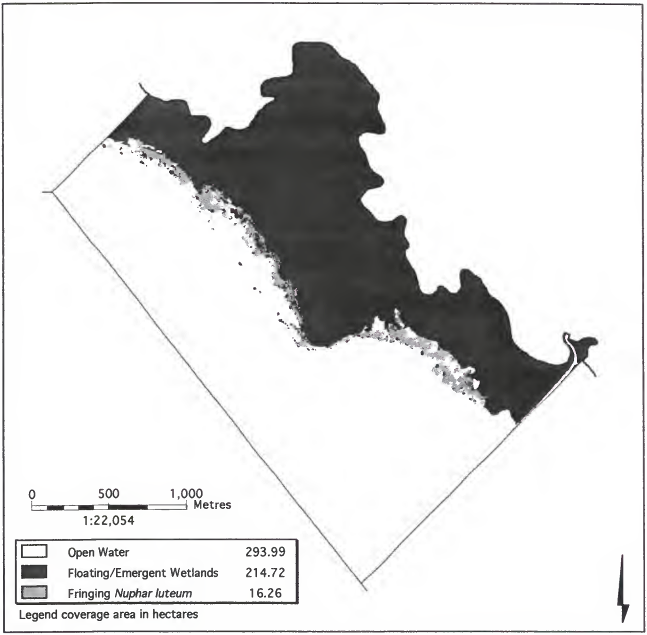

0
500
1,000
Metres
1:22,054
☐ Open Water 293.99
■ Floating/Emergent Wetlands 214.72
▨ Fringing *Nuphar luteum* 16.26
Legend coverage area in hectares

Figure E-6. East(north) Sector, June 13, 1996.

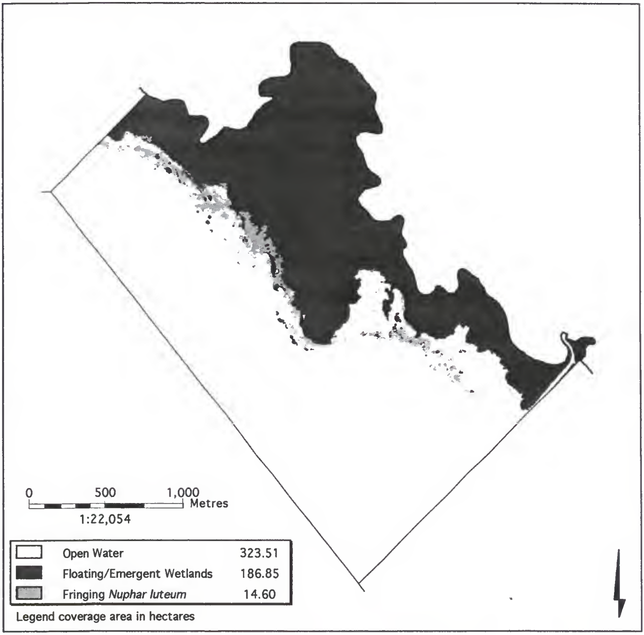

0
500
1,000
Metres
1:22,054
Open Water 323.51
Floating/Emergent Wetlands 186.85
Fringing *Nuphar luteum* 14.60
Legend coverage area in hectares

Figure E-7. East(north) Sector, July 23, 1996.

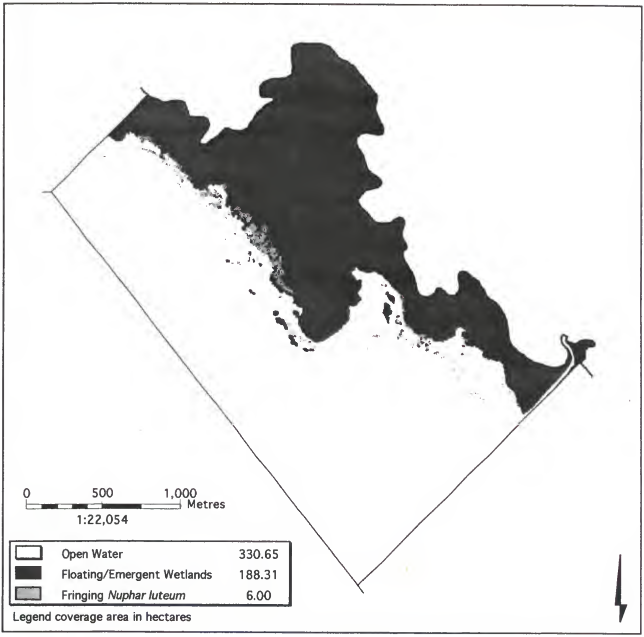

0
500
1,000
Metres
1:22,054
Open Water 330.65
Floating/Emergent Wetlands 188.31
Fringing *Nuphar luteum* 6.00
Legend coverage area in hectares

Figure E-8. East(north) Sector, September 24, 1996.

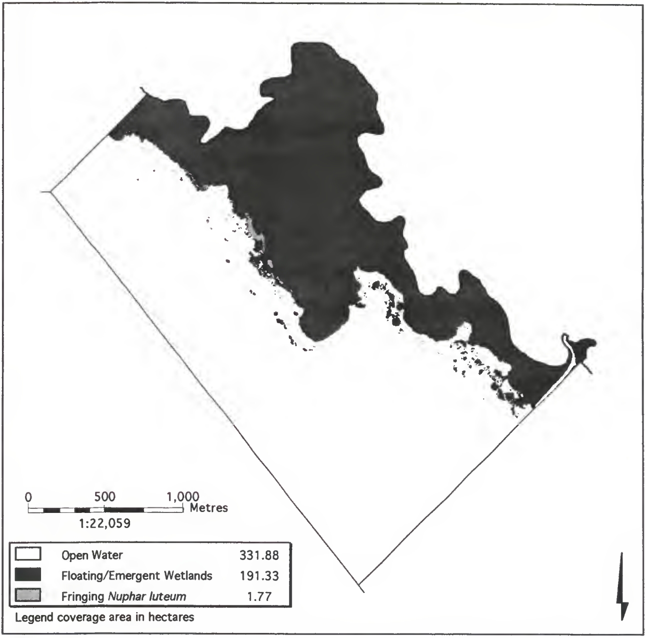
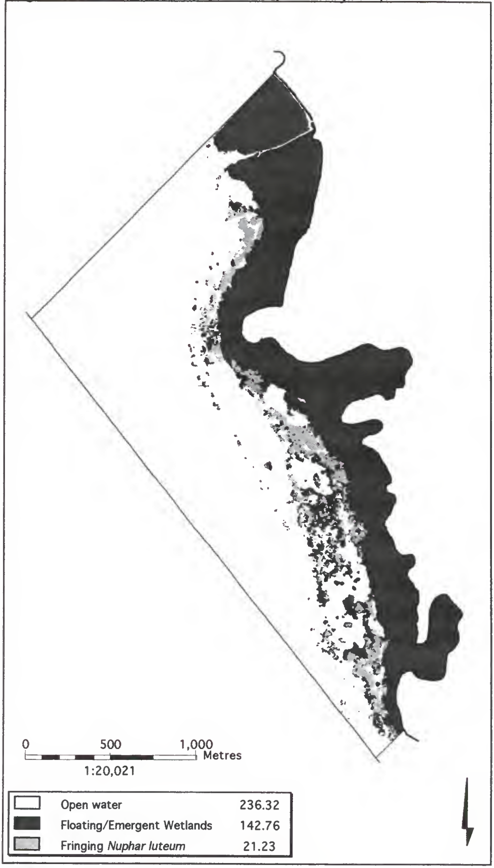

0
500
1,000
Metres
1:22,059
Open Water 331.88
Floating/Emergent Wetlands 191.33
Fringing *Nuphar luteum* 1.77
Legend coverage area in hectares

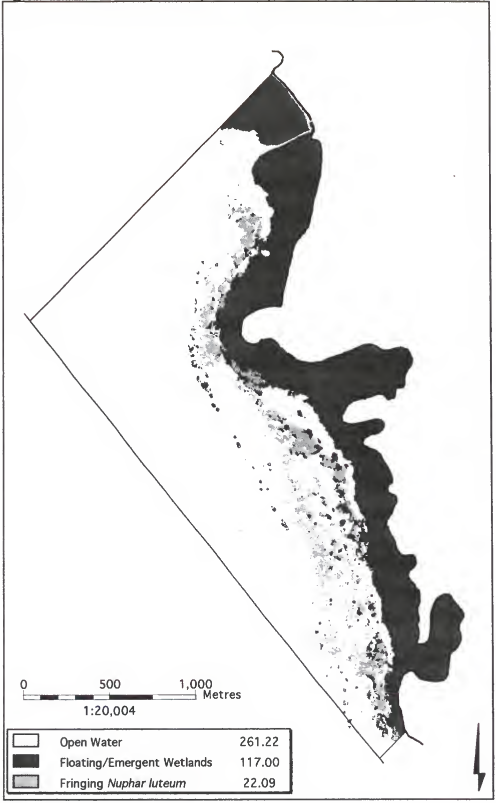
Figure E -9. East(south) Sector, January 22, 1994.



☐	Open water	236.32
■	Floating/Emergent Wetlands	142.76
▨	Fringing *Nuphar luteum*	21.23

Legend area coverage in hectares

Figure E-10. East(south) Sector, June 13, 1996.


0
500
1,000
Metres
1:20,004
☐ Open Water 261.22
■ Floating/Emergent Wetlands 117.00
▨ Fringing *Nuphar luteum* 22.09

Legend area coverage in hectares

Figure E-11. East(south) Sector, July 23, 1996.

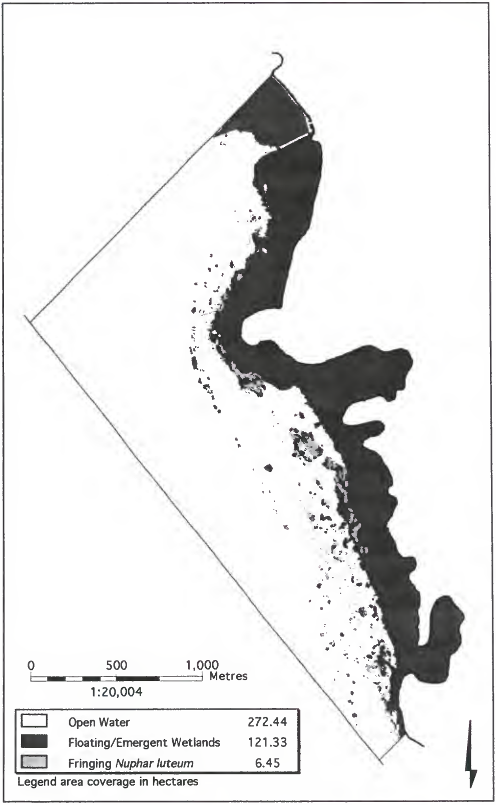

0
500
1,000
Metres
1:20,004
☐ Open Water 272.44
■ Floating/Emergent Wetlands 121.33
▨ Fringing *Nuphar luteum* 6.45
Legend area coverage in hectares

Figure E-12. East(south) Sector, September 24, 1996.

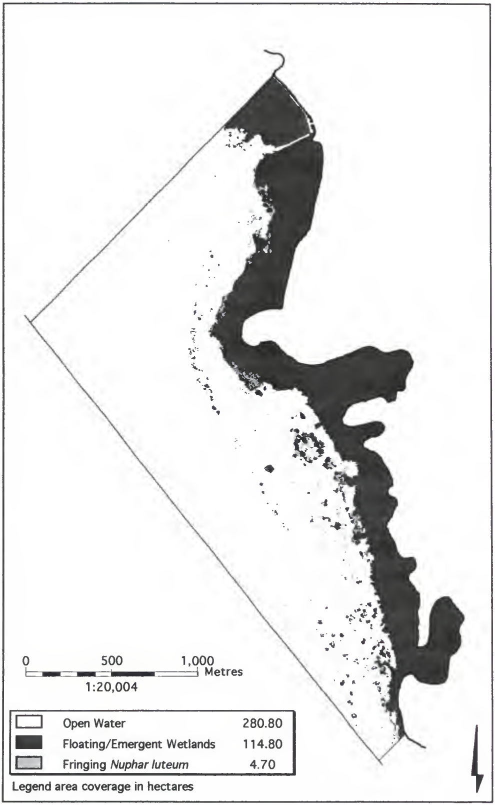
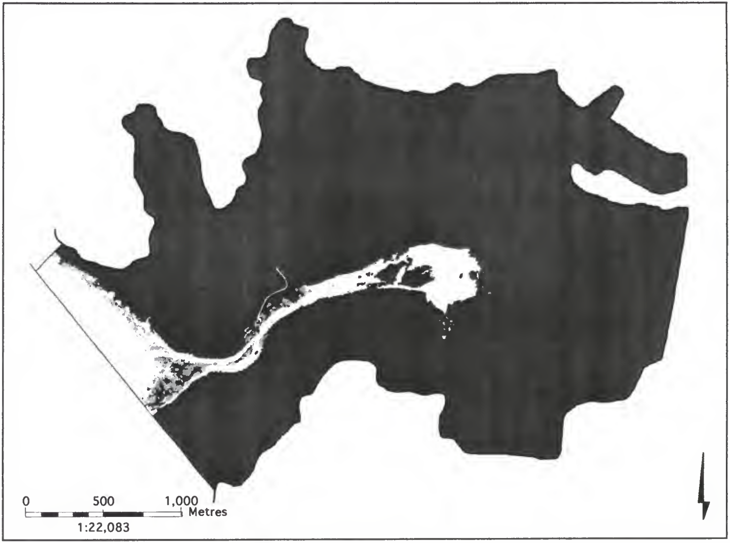

0
500
1,000
Metres
1:20,004
Open Water 280.80
Floating/Emergent Wetlands 114.80
Fringing *Nuphar luteum* 4.70
Legend area coverage in hectares

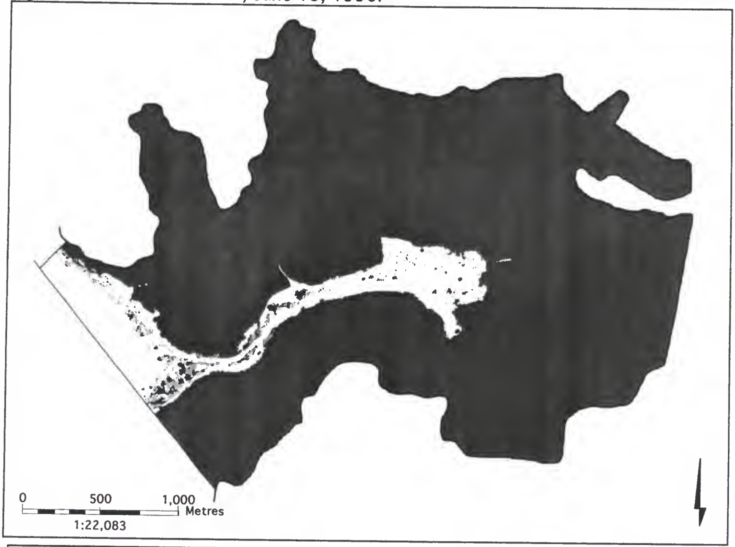
Figure E-13. PG Run Sector, January 22 1994.



☐	Open Water	54.21
■	Floating/Emergent Wetlands	665.04
▨	Fringing *Nuphar luteum*	7.60

Legend coverage area in hectares

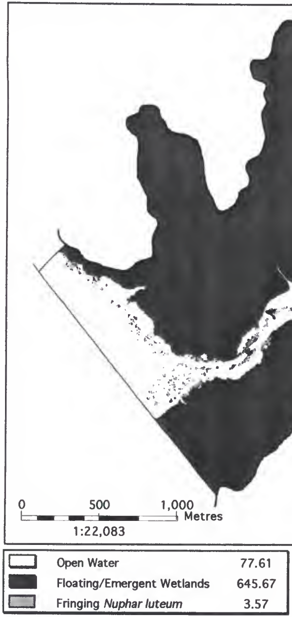
Figure E-14. PG Run Sector, June 13, 1996.



☐	Open Water	72.43
■	Floating/Emergent Wetlands	647.73
▨	Fringing *Nuphar luteum*	6.56

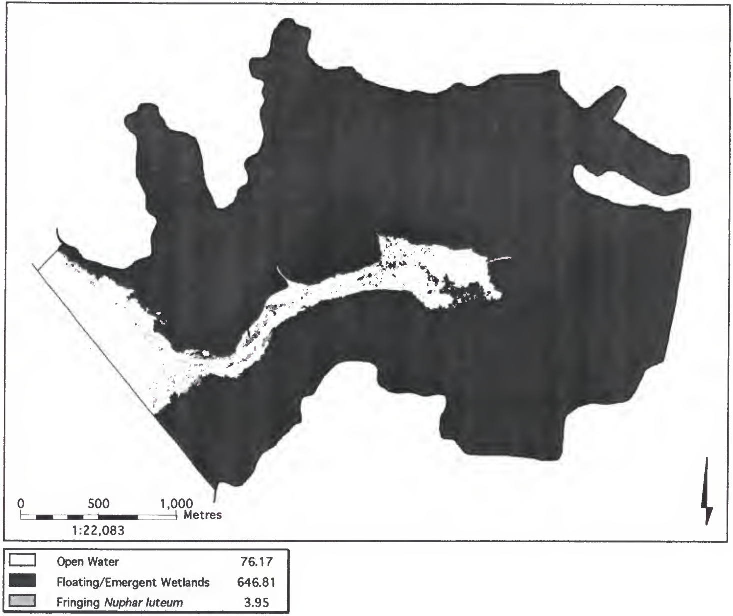
Legend coverage area in hectares

Figure E-15. PG Run Sector, July 23, 1996.


0
500
1,000
Metres
1:22,083
Open Water 77.61
Floating/Emergent Wetlands 645.67
Fringing *Nuphar luteum* 3.57

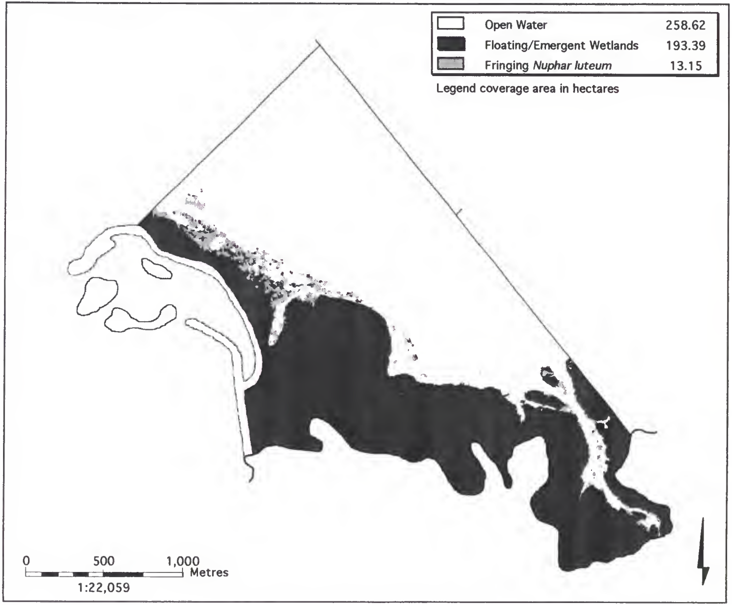
Legend coverage area in hectares

Figure E-16. PG Run Sector, September 24, 1996.


0
500
1,000
Metres
1:22,083
□ Open Water 76.17
■ Floating/Emergent Wetlands 646.81
▨ Fringing *Nuphar luteum* 3.95

Legend coverage area in hectares

Figure E-17. South Sector, January 22, 1994.



Open Water 258.62
Floating/Emergent Wetlands 193.39
Fringing *Nuphar luteum* 13.15
Legend coverage area in hectares
0
500
1,000
Metres
1:22,059

Figure E-18. South Sector, June 13, 1996.

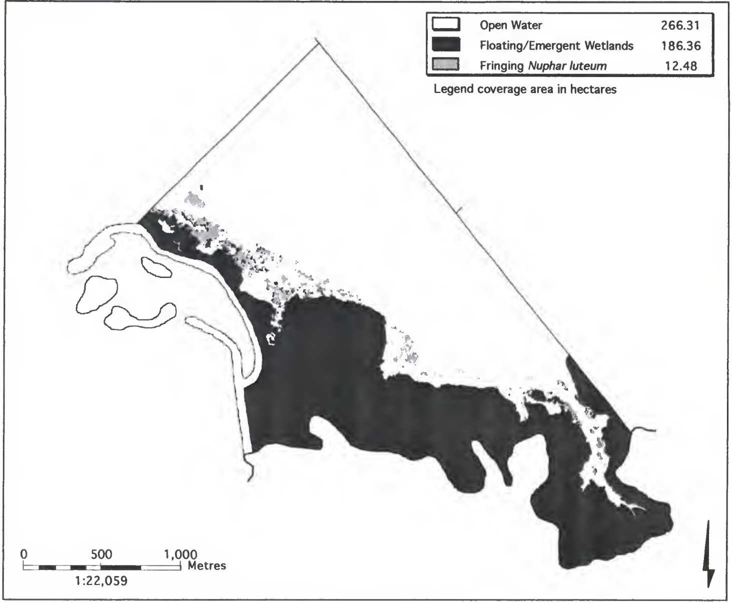

Open Water 266.31
Floating/Emergent Wetlands 186.36
Fringing *Nuphar luteum* 12.48
Legend coverage area in hectares
0
500
1,000
Metres
1:22,059

Figure E-19. South Sector, July 23, 1996.

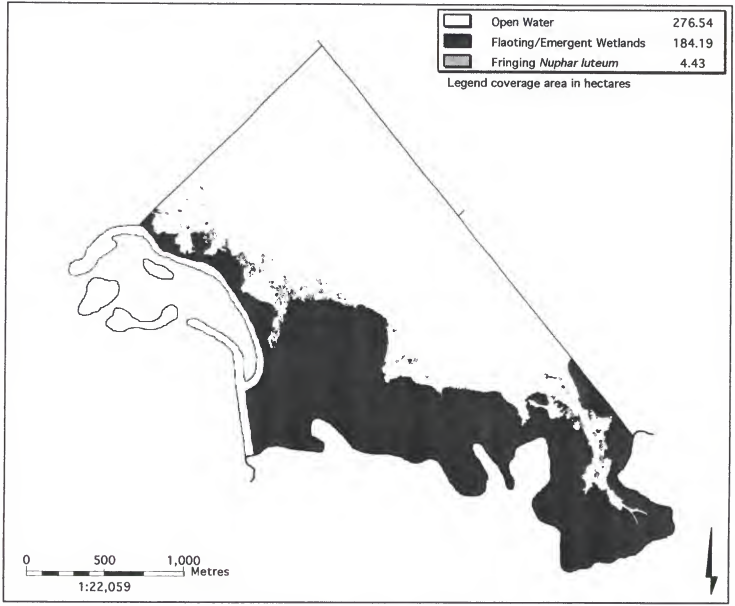

Open Water 276.54
Flaoting/Emergent Wetlands 184.19
Fringing *Nuphar luteum* 4.43
Legend coverage area in hectares
0
500
1,000
Metres
1:22,059

Figure E-20. South Sector, September 24, 1996.

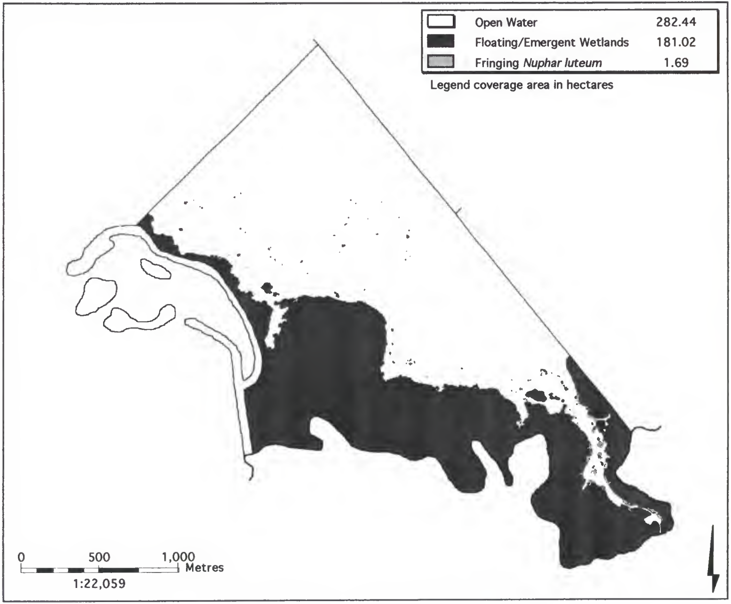
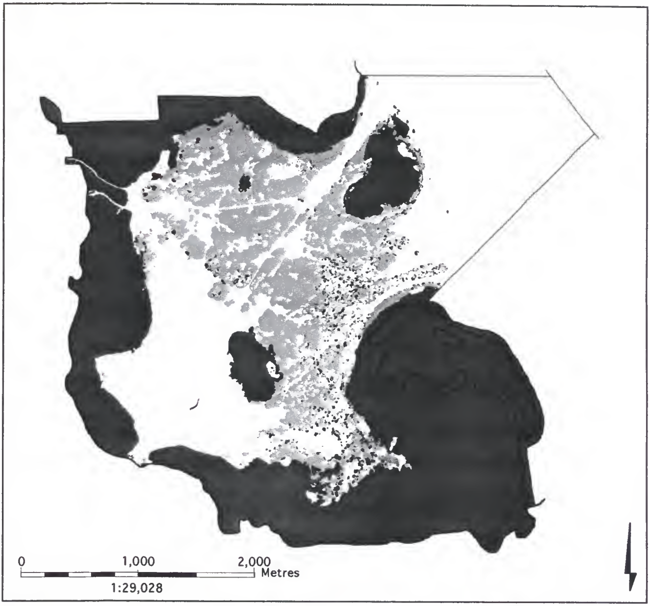

Open Water 282.44
Floating/Emergent Wetlands 181.02
Fringing *Nuphar luteum* 1.69
Legend coverage area in hectares
0
500
1,000
Metres
1:22,059

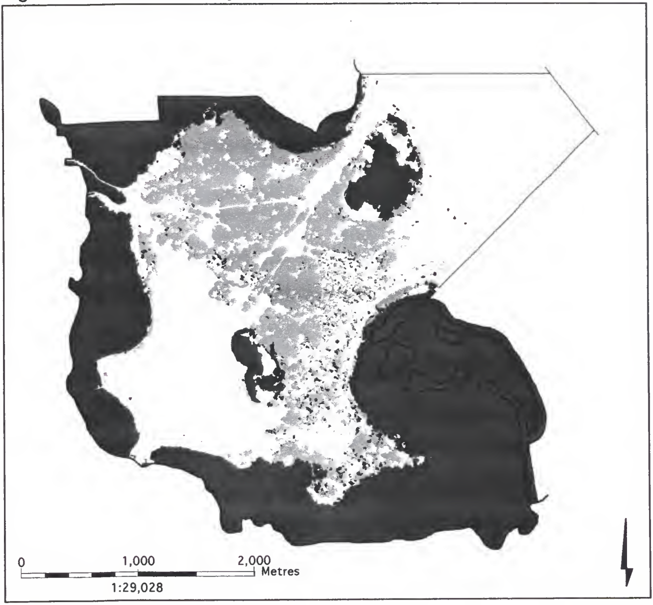
Figure E-21. MacIntosh Bay Sector, January 22, 1994.



□	Open Water	488.66
■	Floating/Emergent Wetlands	589.19
▨	Fringing *Nuphar luteum*	245.77

Legend coverage area in hectares

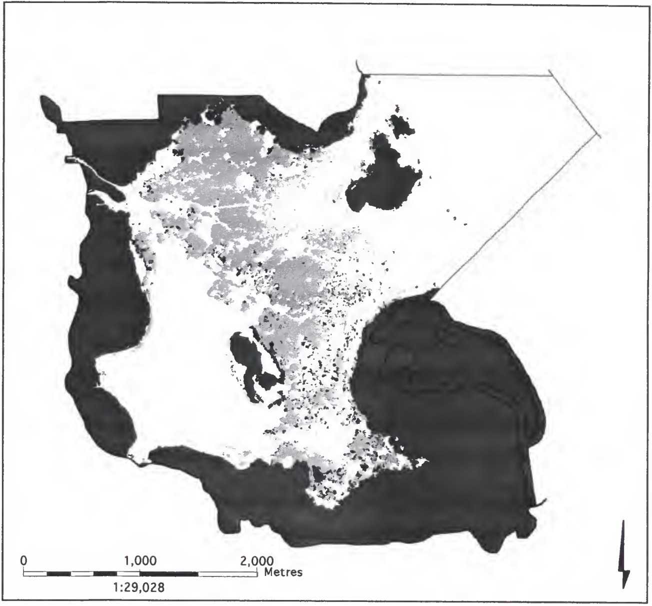
Figure E-22. MacIntosh Bay Sector, June 13, 1996.



☐	Open Water	520.38
■	Floating/Emergent Wetlands	556.72
▨	Fringing *Nuphar luteum*	246.51

Legend coverage area in hectares

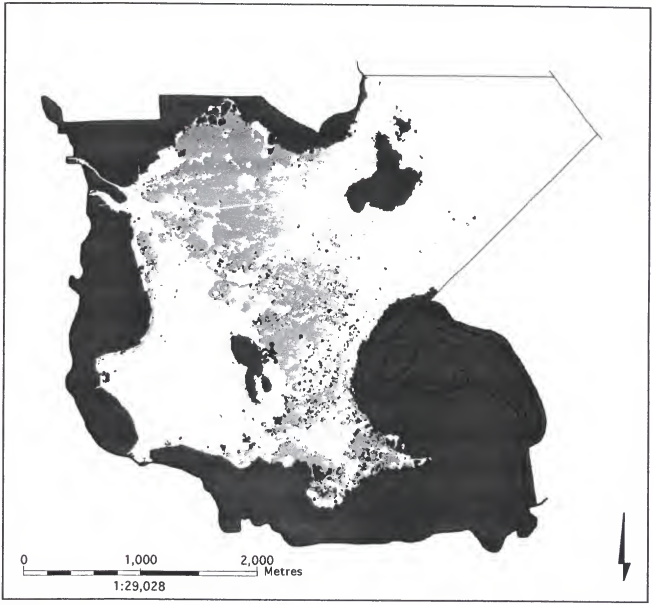
Figure E-23. MacIntosh Bay Sector, July 23, 1996.



☐	Open Water	574.60
■	Floating/Emergent Wetlands	555.07
▨	Fringing *Nuphar luteum*	193.95

Legend coverage area in hectares

Figure E-24. MacIntosh Bay Sector, September 24, 1996.



☐	Open Water	596.56
■	Floating/Emergent Wetlands	553.51
▨	Fringing *Nuphar luteum*	173.55

Legend coverage area in hectares

Figure E-25. West Sector, January 22, 1994.

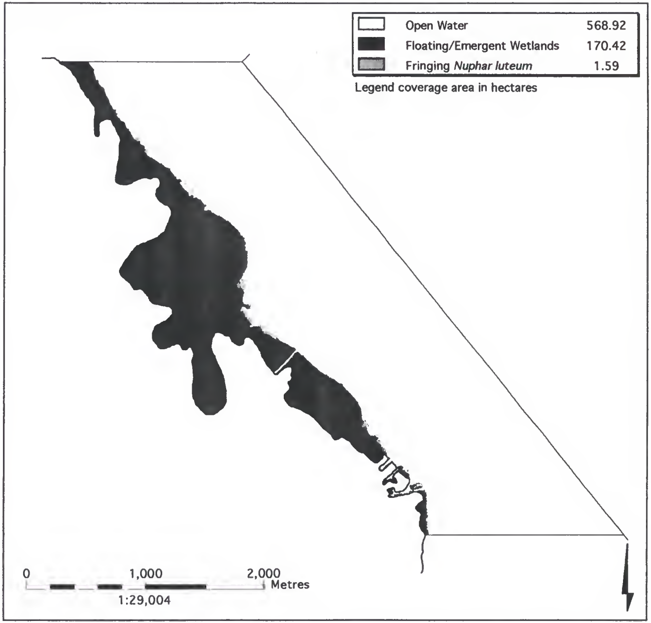

Open Water 568.92
Floating/Emergent Wetlands 170.42
Fringing *Nuphar luteum* 1.59
Legend coverage area in hectares
0
1,000
2,000
Metres
1:29,004

Figure E-26. West Sector, June 13, 1996.

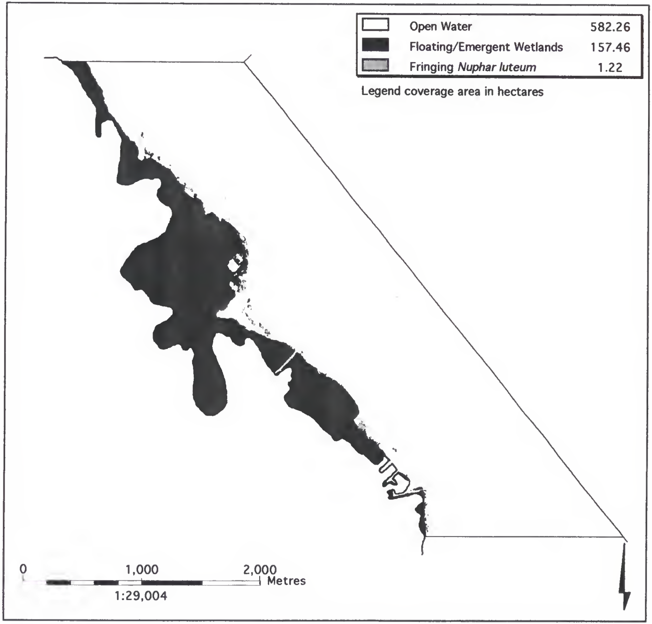

□ Open Water 582.26
■ Floating/Emergent Wetlands 157.46
▨ Fringing *Nuphar luteum* 1.22
Legend coverage area in hectares
0
1,000
2,000
Metres
1:29,004

Figure E-27. West Sector, July 23, 1996.

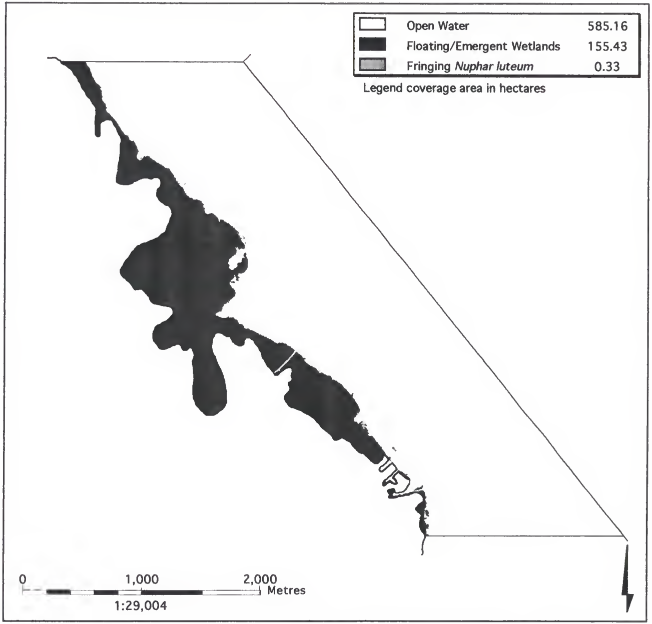
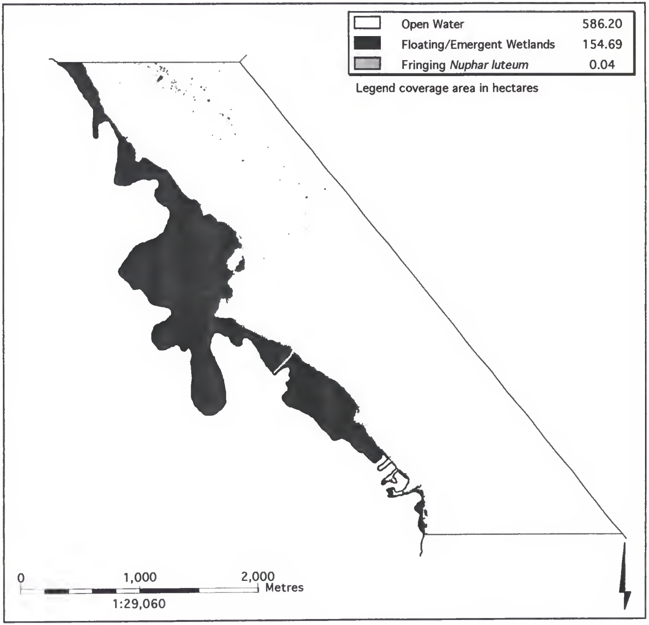
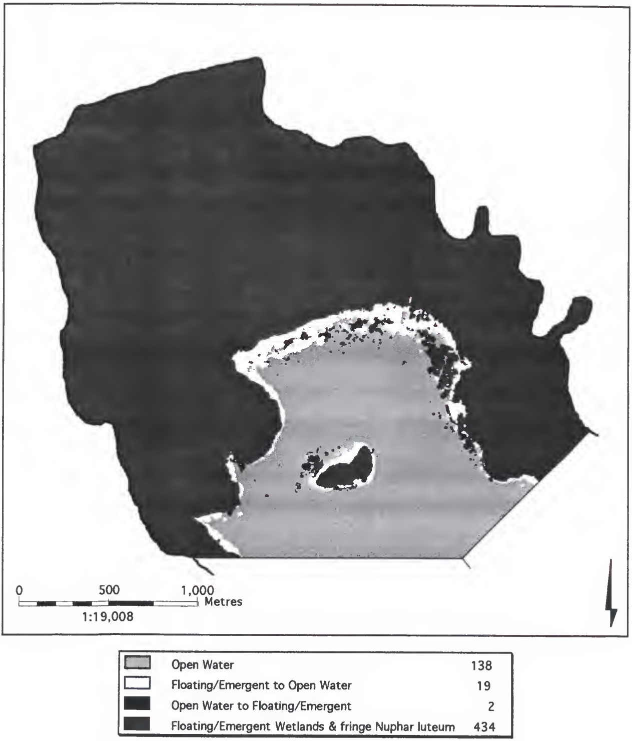

Open Water 585.16
Floating/Emergent Wetlands 155.43
Fringing *Nuphar luteum* 0.33
Legend coverage area in hectares
0
1,000
2,000
Metres
1:29,004

Figure E-28. West Sector, September 24, 1996.

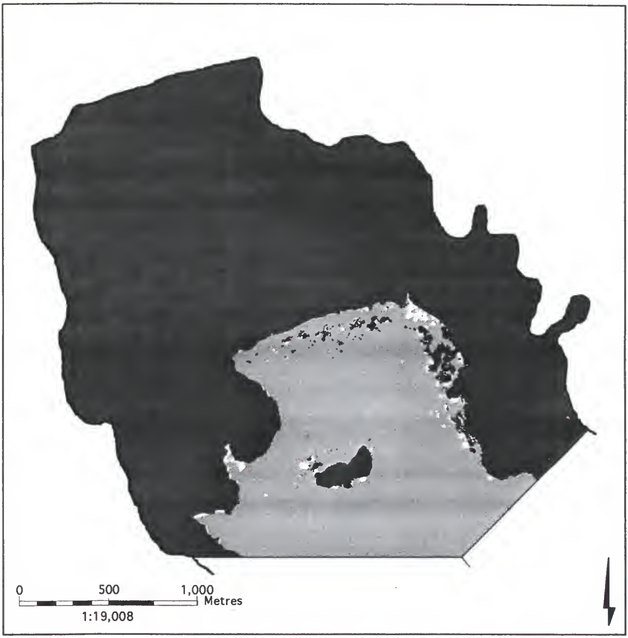

Open Water 586.20
Floating/Emergent Wetlands 154.69
Fringing *Nuphar luteum* 0.04
Legend coverage area in hectares
0
1,000
2,000
Metres
1:29,060



▒	Open Water	138
☐	Floating/Emergent to Open Water	19
■	Open Water to Floating/Emergent	2
▩	Floating/Emergent Wetlands & fringe Nuphar luteum	434

Legend coverage area in hectares

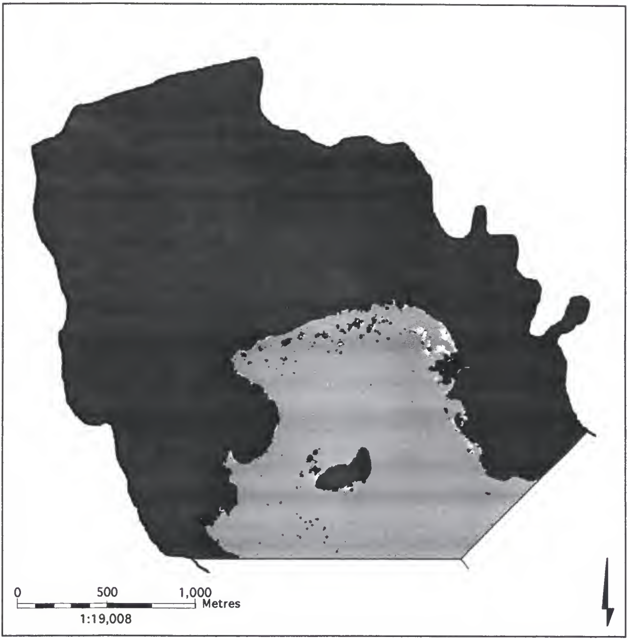
Figure E-29. North Sector, change between January 22, 1994 and June 23, 1996



▒	Open Water	157
□	Floating/Emergent to Open Water	4
■	Open Water to Floating/Emergent	2
▓	Floating/Emergent Wetlands & fringe *Nuphar luteum*	415

Legend coverage area in hectares

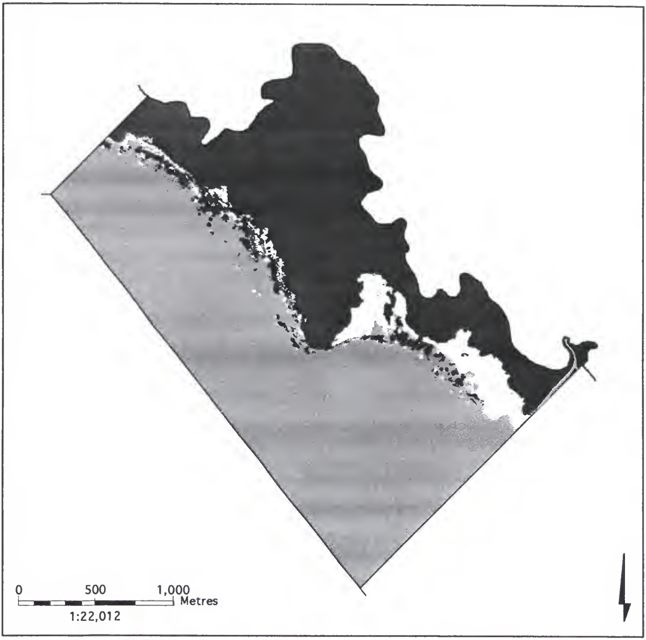
Figure E-30. North Sector, change between June 13 and July 23, 1996



▒	Open Water	159
□	Floating/Emergent to Open Water	2
■	Open Water to Floating/Emergent	5.2
▩	Floating/Emergents Wetlands & fringe *Nuphar luteum*	416

Legend coverage area in hectares

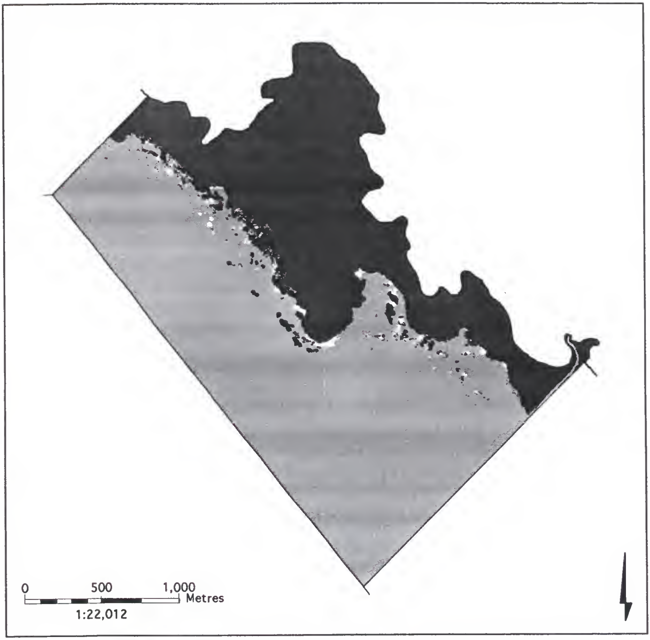
Figure E-31. North Sector, change between July 23 and September 24, 1996



▒	Open Water	297
☐	Floating/Emergent to Open Water	30
■	Open Water to Floating/Emergent	3
▓	Floating/Emergent Wetlands & fringe *Nuphar luteum*	195

Legend coverage area in hectares

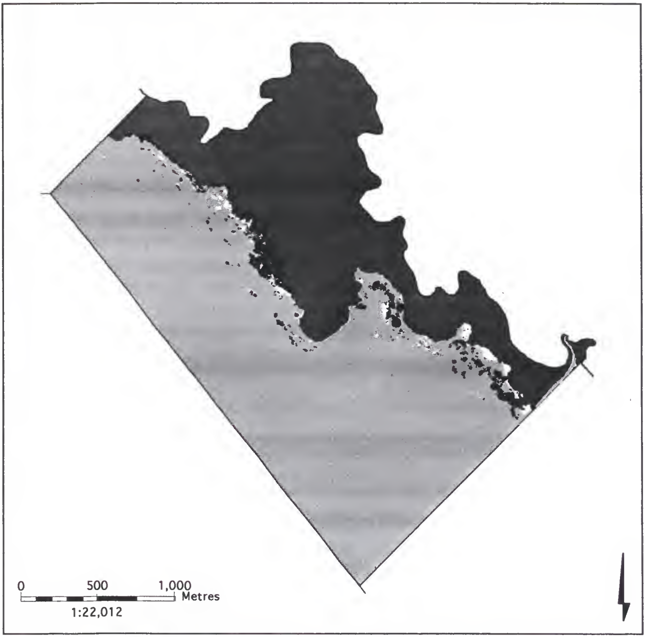
Figure E-32. East(north) Sector, change between January 22, 1994 and June 13, 1996



▒	Open Water	327
□	Floating/Emergent to Open Water	4
■	Open Water to Floating ▯▯▯▯/Emergent	6
■	Floating/Emergent Wetland & fringe *Nuphar luteum*	327

Legend coverage area in hectares

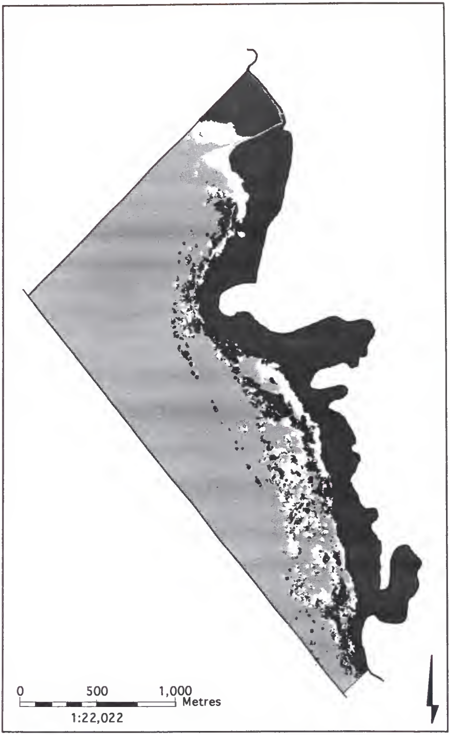
Figure E-33. East(north) Sector, change between June 13 and July 23, 1996



▒	Open Water	327
☐	Floating/Emergent to Open Water	5
■	Open Water to Floating/Emergent	9
▓	Floating/Emergent Wetlands & fringe Nuphar luteum	184

Legend coverage area in hectares

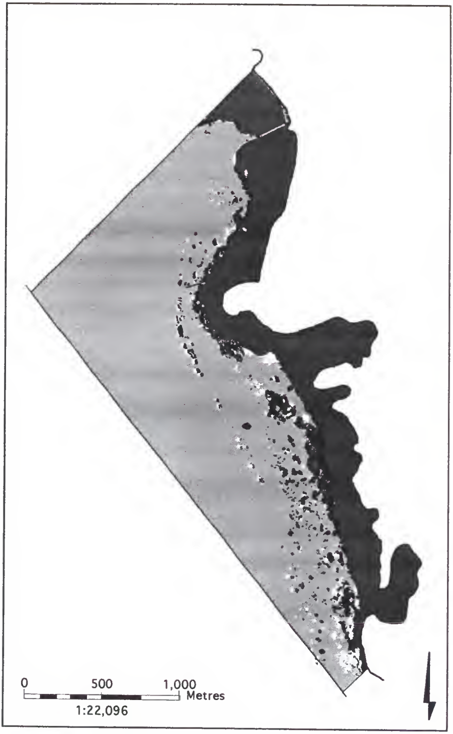
Figure E-34. East(north) Sector, change between July 23 and September 24, 1996



▒	Open Water	235
□	Floating/Emergent to Open Water	32
■	Open water to Floating/Emergent	6
▓	Floating/Emergent Wetlands & fringe *Nuphar luteum*	128

Legend area coverage in hectares

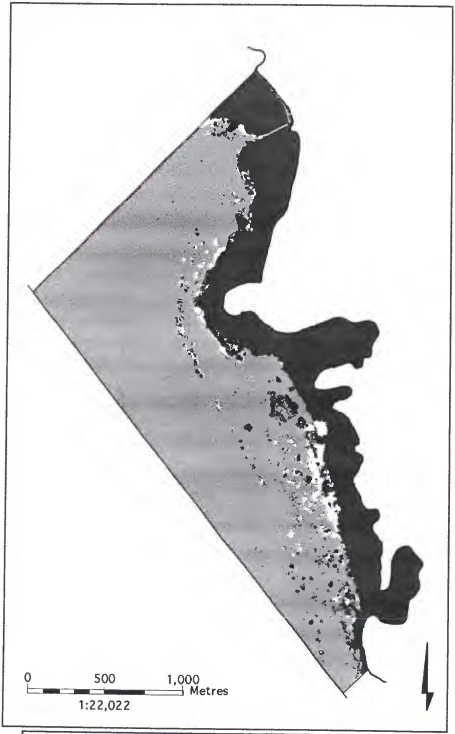
Figure E-35. East(south) Sector, change between January 22, 1994 and June 13, 1996



▒	Open Water	266
□	Floating/Emergent to Open Water	8
■	Open Water to Floating/Emergent	12
▓	Floating/Emergent Wetland & fringe Nuphar luteum	114

Legend coverage area in hectares

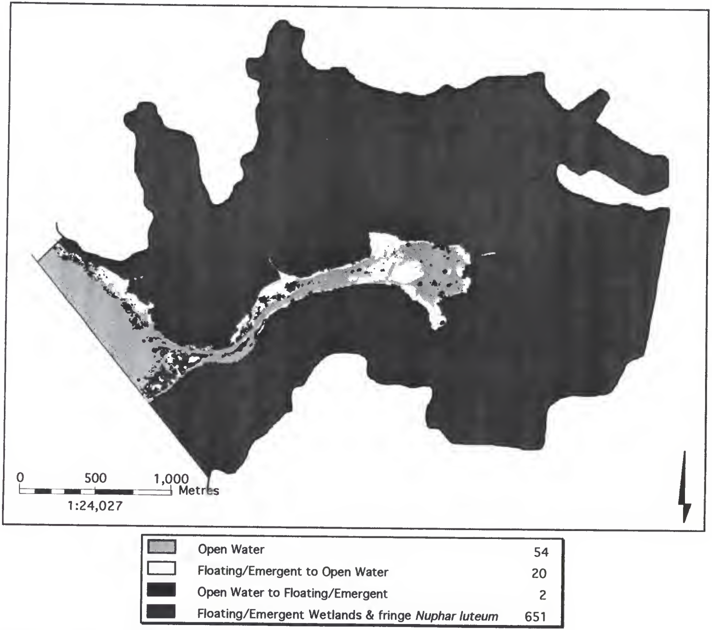
Figure E-36. East(south) Sector, change between June 13 and July 23, 1996



▨	Open Water	273
☐	Floating/Emergent to Open Water	10
■	Open Water to Floating/Emergent	4
■	Floating/Emergent Wetlands & fringe Nuphar luteum	114

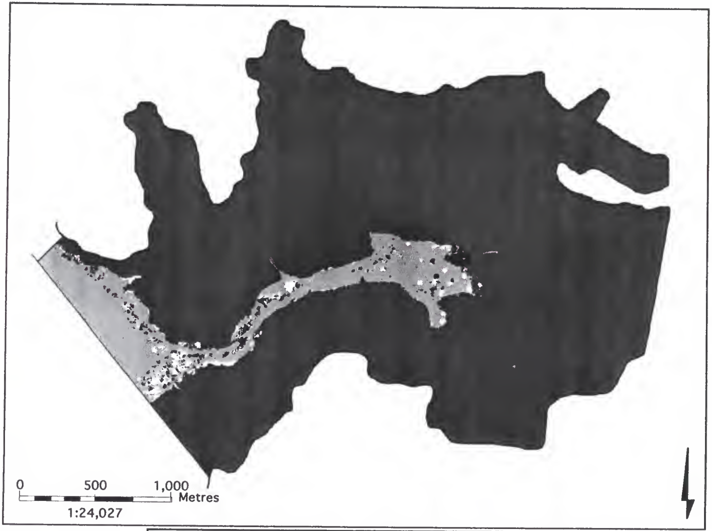
Legend coverage area in hectares

Figure E-37. East(south) Sector, change between July 23 and Septembre, 1996


0
500
1,000
Metres
1:24,027
Open Water 54
Floating/Emergent to Open Water 20
Open Water to Floating/Emergent 2
Floating/Emergent Wetlands & fringe *Nuphar luteum* 651

Legend coverage area in hectares

Figure E-38. PG Run Sector, change between January 22, 1994 and June 13, 1996



▨	Open Water	71
□	Floating/Emergent to Open Water	7
■	Open Water to Floating/Emergent	5
■	Floating/Emergent Wetlands & fringe Nuphar luteum	643

Legend coverage area in hectares

Figure E-39. PG Run Sector, change between June 13 and July 23, 1996

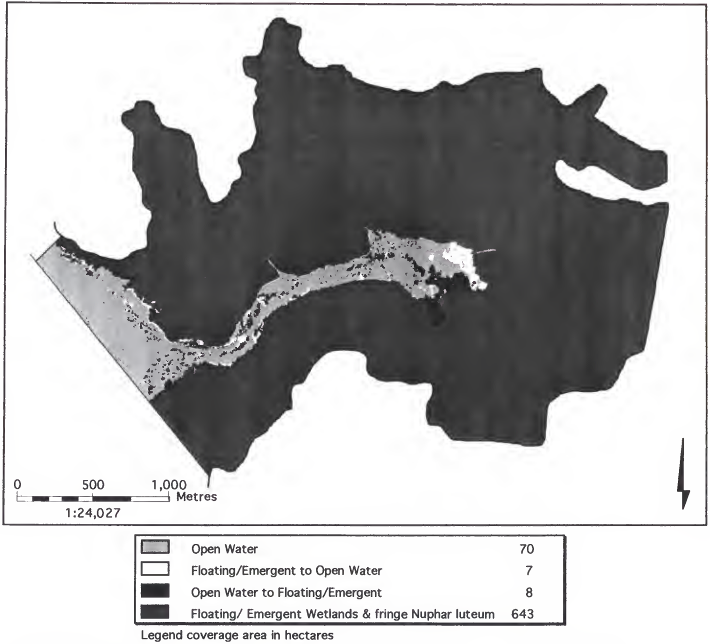
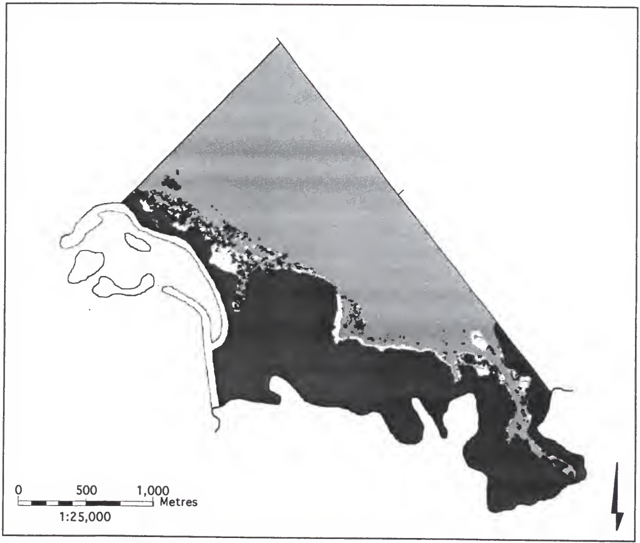

0
500
1,000
Metres
1:24,027
Open Water 70
Floating/Emergent to Open Water 7
Open Water to Floating/Emergent 8
Floating/ Emergent Wetlands & fringe Nuphar luteum 643
Legend coverage area in hectares

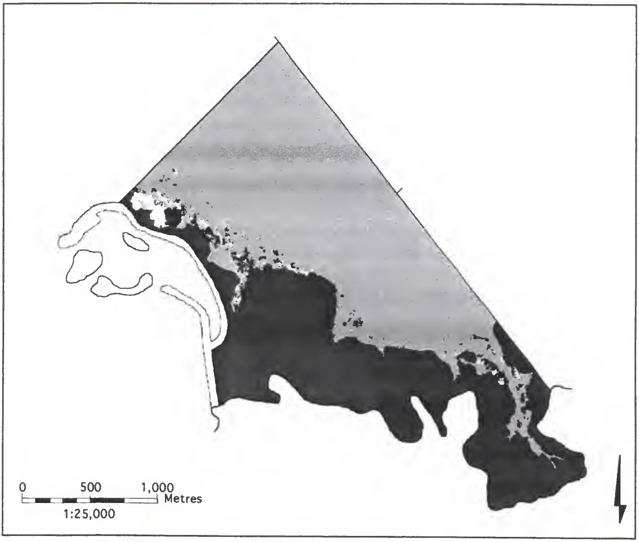
Figure E-40. PG Run Sector, change between July 23 and September 24, 1996



▨	Open Water	256
□	Floating/Emergent to Open Water	13
■	Open Water to Floating/Emergent	5
▩	Floating/Emergent Wetlands & fringe Nuphar luteum	192

Legend coverage area in hectares

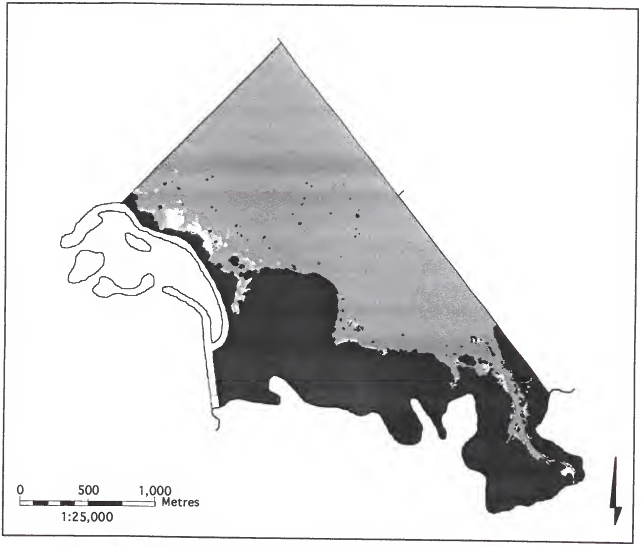
Figure E-41. South Sector, change between January 22, 1994 and June 13, 1996



▒	Open Water	270
☐	Floating/Emergent to Open Water	7
■	Open Water to Floating/Emergent	4
▓	Floating/Emergent Wetlands & fringe *Nuphar luteum*	184

Legend coverage area in hectares

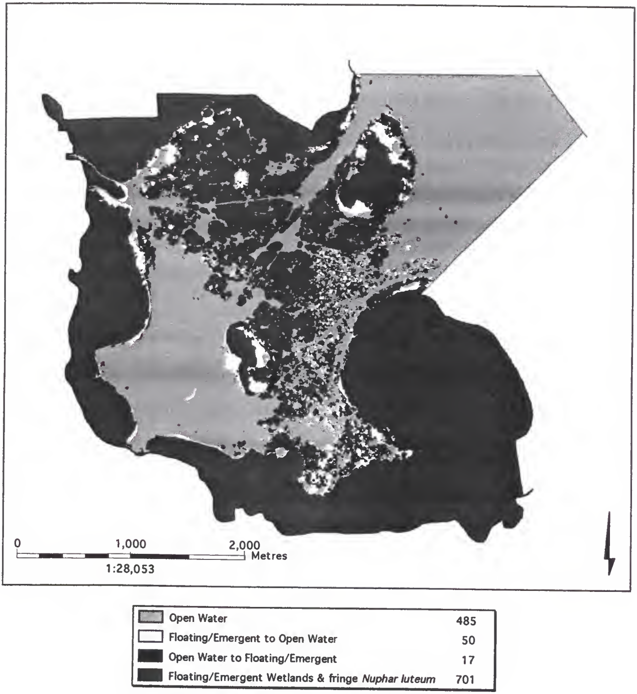
Figure E-42. South Sector, change between June 13 and July 23, 1996



▒	Open Water	275
☐	Floating/Emergent to Open Water	8
■	Open Water to Floating/Emergent	5
▓	Floating/Emergent Wetlands & fringe *Nuphar luteum*	177

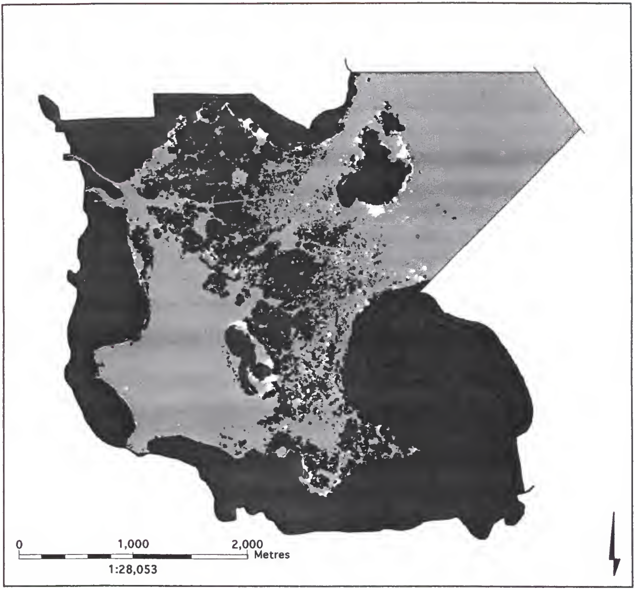
Legend coverage area in hectares

Figure E-43. South Sector, change between July 23 and September 24, 1996


0
1,000
2,000
Metres
1:28,053
Open Water 485
Floating/Emergent to Open Water 50
Open Water to Floating/Emergent 17
Floating/Emergent Wetlands & fringe *Nuphar luteum* 701

Legend coverage area in hectares

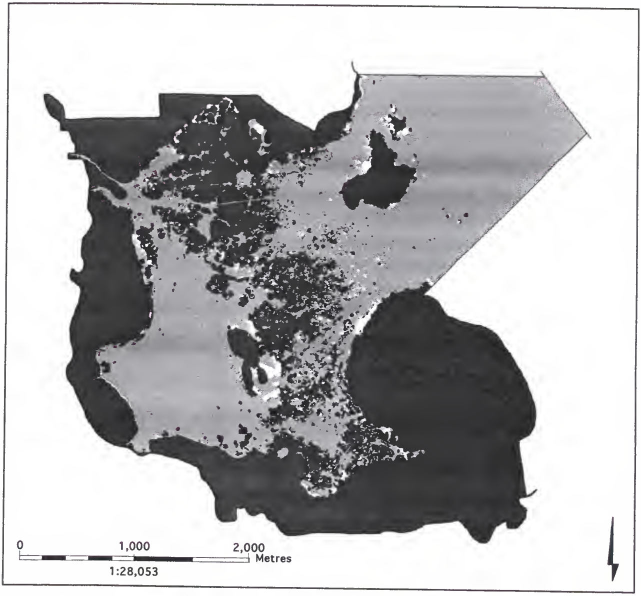
Figure E-44. MacIntosh Bay Sector, change between January 22, 1994 and June 13, 1996



▨	Open Water	558
☐	Floating/Emergent to Open Water	23
■	Open Water to Floating/Emergent	21
■	Floating/Emergent Wetlands & fringe *Nuphar luteum*	722

Legend coverage area in hectares

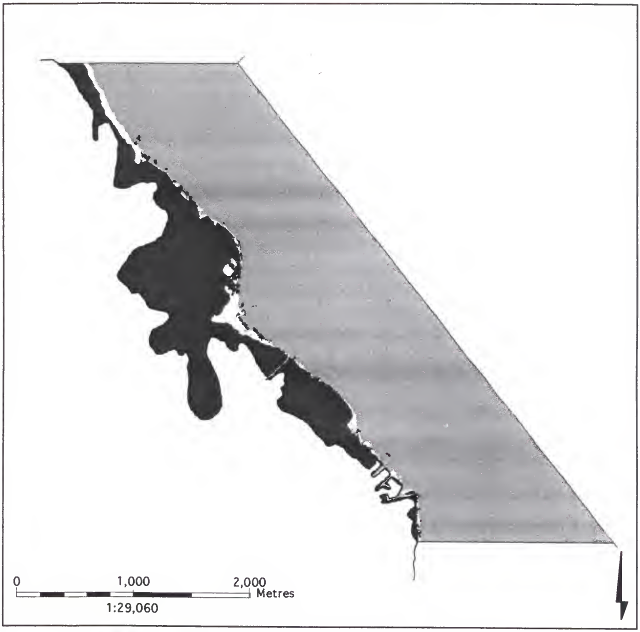
Figure E-45. MacIntosh Bay Sector, change between June 13 and July 23, 1996



▨	Open Water	577
□	Floating/Emergent to Open Water	25
■	Open Water to Floating/Emergent	23
■	Floating/Emergent Wetlands & fringe *Nuphar luteum*	698

Legend coverage area in hectares

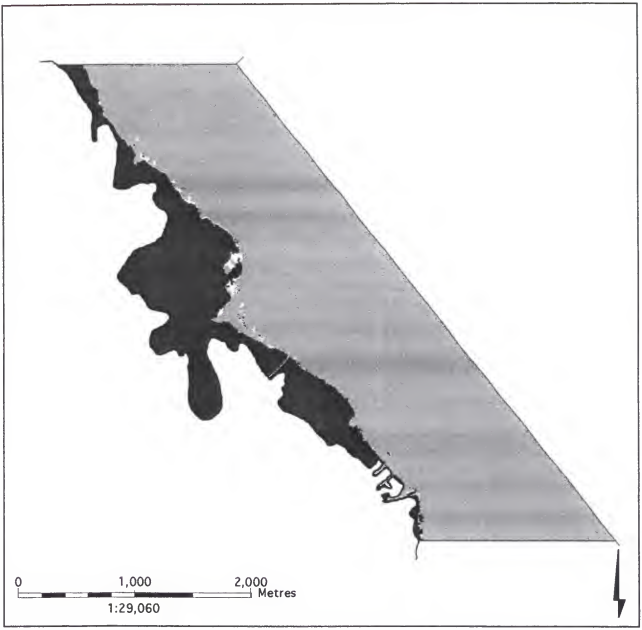
Figure E-46. MacIntosh Bay Sector, change between July 23 and September 24, 1996



▒	Open Water	568
□	Floating/Emergent to Open Water	15
■	Open Water to Floating/Emergent	2
▩	Floating/Emergent Wetlands & fringe *Nuphar luteum*	157

Legend coverage area in hectares

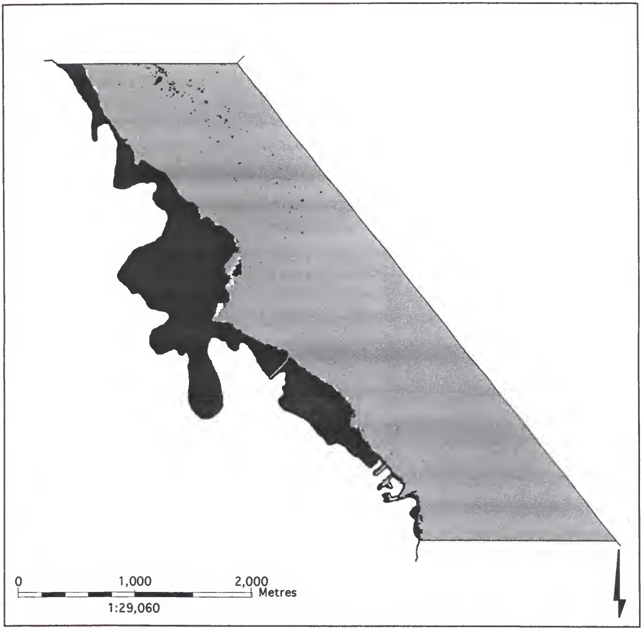
Figure E-47. West Sector, change between January 22, 1994 and June 13, 1996



░	Open Water	581
□	Floating/Emergent to Open Water	4
■	Open Water to Floating/Emergent	2
▓	Floating/Emergent Wetlands & fringe *Nuphar luteum*	153

Legend coverage area in hectares

Figure E-48. West Sector, change between June 13 and July 23, 1996



▒	Open Water	283
☐	Floating/Emergent to Open Water	3
■	Open Water to Floating/Emergent	2
■	Floating/Emergent Wetlands & fringe Nuphar luteum	153

Legend coverage area in hectares

Figure E-49. West Sector, change between July 23 and September 24, 1996

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Mark Clark was born July 17, 1964, in San Rafael, California. He entered Southeastern Massachusetts University in September 1982, where he received a Bachelor of Science in Marine Biology in 1986. After he graduated Mark worked in mariculture of *Aplysia californica* and marine algal species at Woods Hole, Massachusetts, was chief engineer aboard the research vessel *Acania* studying Humpback Whales in Southeast Alaska, and oversaw the construction of a new *Aplysia* Resource Facility at the University of Miami's Rosensteil School of Marine and Atmospheric Science. In 1989, Mark accepted a research scientist position with the Florida Keys Land and Sea Trust based in Marathon, Florida. In this position he conducted a baseline survey of water column nutrients throughout the Florida Keys, conducted experiments on nutrient uptake dynamics of marine algal species for application in wastewater treatment and oversaw the Land & Sea Trust's marine education programs. He was accepted at the University of Florida to pursue his Masters of Science degree in the Department of Environmental Engineering Sciences in the Fall of 1992. He began his doctoral program in 1995 and has held graduate teaching and research assistantships while completing his dissertation of the Doctor of Philosophy degree.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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